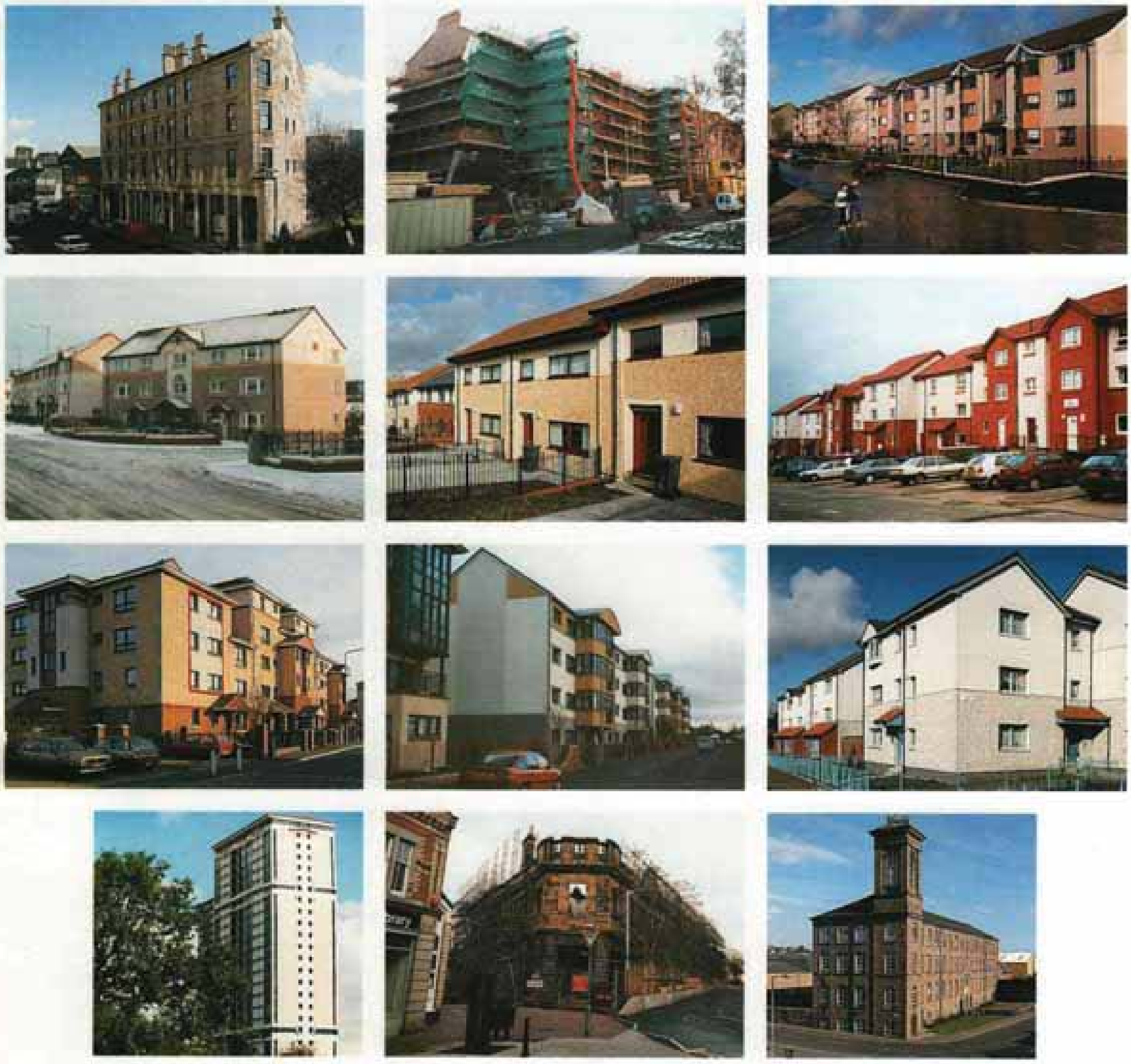
DEPARTMENT OF THE ENVIRONMENT

GENERAL INFORMATION REPORT 46

Energy efficiency in Scottish Housing Association refurbishment projects



Scottish Homes
THE NATIONAL HOUSING AGENCY

BEST PRACTICE PROGRAMME
ENERGY EFFICIENCY

BEST PRACTICE
PROGRAMME

GENERAL INFORMATION REPORT 46

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SUMMARY

This Report is aimed at Scottish housing associations and building professionals working with them. It will also be of general interest to those involved in refurbishment projects.

Background

The purpose of this project was to investigate the opportunities for improving the energy efficiency of Scottish housing association refurbishment projects within planned work programmes. The project was funded by the Department of the Environment (DOE) and Scottish Homes.

The study aimed to establish how current housing association specifications for refurbishment works could achieve a higher standard of energy efficiency cost-effectively. The use of energy ratings was investigated as a means of setting effective energy targets. The study follows on from earlier work by BRECSU which has led to minimum Standard Assessment Procedure (SAP) ratings being set by the Housing Corporation for refurbished properties in England[1]. The results of the study may inform any future Scottish Homes energy efficiency policy.

Methodology

Housing associations were made aware of the proposed research and asked to submit details of suitable refurbishment projects. From a total of 28 projects submitted, 12 were selected as representative samples of types of property and size of association. Seven of the projects were at the design or approval stage and five were projects that had been completed within the previous 10 years, and which were included as examples of good practice.

The Government's Standard Assessment Procedure (SAP)[2] for home energy rating was used to assess the likely energy efficiency performance of different dwelling types. Further, more detailed, analysis using the Building Research Establishment Domestic Energy Model (BREDEM) computer program was undertaken to assess the cost-effectiveness of each of the energy efficiency measures included in the specification. The housing associations were then given details of this analysis and any recommended amendments and additions to the specification for the seven current projects. The associations supplied details of the actual costs of the energy efficiency measures that were incorporated. Buildability issues identified on site, and the role and reactions of the tenants were also examined.

Results

Generally, a high standard of energy efficiency was achieved by the associations. After completion of the seven 'current' projects, the SAP ratings of the most energy efficient dwellings were all above 85 and the SAP ratings of almost all of the least energy efficient dwellings were above 75. Annual energy costs were estimated to have reduced on average by 69% from £481 to £149, with a resultant reduction of 56% in carbon dioxide (CO_2) emissions. However, for the dwellings in this Report, it is likely that some of the benefits will be taken as increased comfort rather than real CO_2 savings.

The level of energy efficiency achieved by the associations generally depended on either their own standard specification or the advice of the architect employed. This was particularly relevant for the smaller associations. The concept of energy targets was not well established although, once highlighted, many associations reported their interest in using the technique in future refurbishment projects.

Energy efficiency measures

A number of different energy efficiency measures were adopted by the various housing associations (see table 1, overleaf). Typical measures that improved upon existing specifications were increasing loft insulation to 200 mm, using more efficient heating systems and increasing internal wall insulation. Some measures, such as low-emissivity (low-e) glazing, were not found to be cost-effective.

Several of the recommended energy efficiency measures were not adopted by the associations, usually because of restricted budgets. Condensing combination boilers were generally regarded as being unproven technology with high maintenance costs. However, the concept of standard combination boilers was well established. The main problems related to the lack of suitable space to site boilers in small properties and the inadequate control of the system by some tenants.

The research confirmed that tenants of the locally based associations had a large influence on the energy efficiency measures selected.

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Table 1 Summary of selected projects

Building type	Association	Project name	Description of project	Date carried out	Heating fuel after refurbishment	Energy saving measures
Traditional tenement	1. Partick	Dumbarton Road	Complete refurbishment of traditional Victorian tenement	1996	gas	Roof insulation Insulated dry lining Close wall insulation Double glazing Extract fans Gas central heating
	2. Cloch	Belville Street	Complete refurbishment of traditional Victorian tenement	1995	gas	Roof insulation Insulated dry lining Close wall insulation Double glazing Extract fans Gas central heating
Low-rise housing: no-fines	3. Bellsmyre	Merkins Avenue	Complete refurbishment of 42 flats in three blocks	1995	gas	Roof insulation External wall insulation Close wall insulation Ground floor insulation Double glazing Extract fans Gas central heating
	4. Forgewood	Fife Drive	Complete refurbishment of 40 flats in five blocks	1996	gas	Roof insulation Insulated dry lining Close wall insulation Ground floor insulation Double glazing Extract fans Gas central heating
Low-rise housing: cross wall	5. GAP	Mull and Iona	Complete refurbishment of 67 1960s terraced houses	1996	gas	Roof insulation External wall insulation Insulated dry lining Double glazing Extract fans Gas central heating
Low-rise housing: cavity wall	6. North View	Birgidale Road	Complete refurbishment of 28 1960s ex-council flats	1995	gas	Roof insulation External wall insulation Close wall insulation Ground floor insulation Double glazing Extract fans Gas central heating

SUMMARY

Table 1 (continued)

Association	Project name	Description of project	Date carried out	Heating fuel after refurbishment	Energy saving measures	Building type
7. Hunters Hall	Niddrie House Phase 1	Complete refurbishment and remodelling of 1970s ex-council housing	1989	gas and electric	Roof insulation Insulated dry lining (Cavity fill) Double glazing Extract fans Gas central heating Electric storage heaters	Low-rise housing: cavity wall
8. James Nisbet Street	James Nisbet Street Phase 2	Complete refurbishment and remodelling of 1960s ex-council flats	1991	gas	Roof insulation External wall insulation Double glazing Extract fans Condensing boilers	Low-rise housing: cavity wall
9. Blairtummock	Aberdalgie Road	Complete refurbishment and remodelling of 1950s ex-council flats	1991	gas	Roof insulation External wall insulation Close wall insulation Double glazing Extract fans Gas central heating	Low-rise housing: cavity wall
10. Scottish Homes	Hutchesontown V	Complete refurbishment of 1960s high-rise flats	1994	gas	Roof insulation Insulated overcladding (Floor insulation) Low-emissivity glazing Double glazing (Extract fans) District heating	High-rise
11. Kingdom	Waggon Road/Durie Street	24 new build flats utilising existing stone façade as front elevation	1996	gas	Roof insulation Insulated dry lining Close wall insulation Ground floor insulation Double glazing Extract fans Condensing boilers	Conversion
12. Hillcrest	Denburn Works	35 one-bedroom flats created within former mill	1992	electric	Roof insulation Insulated dry lining Close wall insulation Suspended ceiling insulation Double glazing Extract fans Electric storage heaters	Conversion

Measures in brackets (eg cavity fill)) were undertaken during the original construction of the housing

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Guidance

A range of recommended measures to be considered for inclusion in refurbishment projects is given in section 8 (page 19). SAP ratings vary according to the size and position of dwellings, and associations are recommended to set both a minimum and a mean SAP target for their designers when setting their energy efficiency policy.

The suggested SAP ratings for dwellings over 50 m^2 floor area are:

- minimum SAP rating of 70 for each dwelling
- mean SAP rating of 75 for all dwellings in a scheme.

Each refurbishment project should be considered individually taking into account all factors, including available funding, type of stock and association policy.

It is easier for larger properties than smaller properties to achieve a higher SAP rating, given the same level of insulation and the same type of heating system. For smaller dwellings, therefore, it may be difficult to achieve the values of 70 and 75 suggested above.

AIMS AND OBJECTIVES

This Report is aimed at Scottish housing associations and building professionals working with them. It will also be of general interest to those involved in refurbishment projects.

1.0 AIMS AND OBJECTIVES

The overall aim of the project was to establish the opportunities for improving the energy efficiency of housing association and housing cooperative dwellings in Scotland. This aim was exemplified by the following main objectives:

- to establish opportunities for improving energy efficiency in existing Scottish housing association properties within planned work programmes
- to demonstrate how energy efficiency can be applied cost-effectively within normal funding mechanisms and cost frameworks
- to demonstrate that tenant consultation is an important part of improving energy efficiency
- to show the value of an integrated strategic approach including energy labelling.

2.0 BACKGROUND

In recent years there has been an improvement in the standard of energy efficiency adopted by housing associations and housing cooperatives when refurbishing their housing stock. Generally their motivation for this has been the desire to provide tenants with affordable warmth. In addition, moves towards higher standards of energy efficiency can reduce both energy use and emissions of CO_2. This is in line with the policy objectives of the Government's 1990 White Paper 'This Common Inheritance'[3].

In May 1993 the then Energy Efficiency Office identified a need to establish housing association refurbishment opportunities in Scotland. This project arose from that proposal and was designed to investigate the possibility of incorporating more cost-effective techniques in existing improvement methods used by housing associations. The work was funded jointly by the Department of the Environment (DOE) and Scottish Homes, and managed by BRECSU. The work was carried out by Building Research Establishment (BRE) Scottish Laboratory and ASSIST Architects, and follows a similar study undertaken in England[1].

Scottish Homes does not at present have common standards for energy efficiency in refurbished properties. However, this study will contribute to the future energy efficiency policy of Scottish Homes. In 1995 the Scottish Federation of Housing Associations called for minimum standards to be set for energy efficiency; for refurbished properties this is a SAP rating of 75[4].

3.0 METHODOLOGY

3.1 Identification and selection of suitable refurbishment projects

Both current and earlier refurbishment projects were selected. This allowed comparisons of current practice to be made with that of recent years.

- Current projects – those that were at the design or approval stage when their participation in the study was considered.
- Earlier projects – those that had been completed to a high standard of energy efficiency within the past ten years and which demonstrate how good practice can be achieved cost-effectively.

Associations were offered the opportunity to participate in the proposed study, while Scottish Homes, ASSIST and BRE also identified potentially suitable projects. All interested associations were asked for basic information regarding their refurbishment project(s).

From a total of 28 suitable projects, seven current and five earlier projects were selected (table 1, page 4). The selection was made so that it was representative of a wide range of Scottish housing association refurbishment projects in terms of building type, size of association and type of project. Full case studies describing each project are enclosed with this Report. The original intention of selecting one project from each of the 11 Scottish Homes districts was not achieved because of the lack of suitable projects in many areas. In the event, the projects selected were located mainly in the central belt of Scotland. In all, 546 flats and 67 houses were included in the 12 selected projects.

The projects included late nineteenth/early twentieth century tenements, conversion of listed former commercial properties, a high-rise block and low-rise constructions of cross wall, no-fines and traditional cavity wall. One project included

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flats above commercial units. The procurement routes were generally traditional, with tenders based on drawings, specifications and conventional bills of quantities.

3.2 Analysis of the projects

3.2.1 Current projects

The seven current projects were included in the study after the detailed design stage had been completed, but before site works started. Thus there were opportunities for additional and/or alternative energy efficiency measures to be proposed by BRE and incorporated in the design.

The associations supplied relevant details, and typical dwelling types were selected from each project. The selection included those dwellings considered to be the best and the worst in terms of energy efficiency. For each dwelling type a range of improvement options was proposed and analysed in conjunction with the measures already being included in the design.

In addition, SAP ratings, estimated annual heating and water costs and the associated CO_2 emissions were calculated using BREDEM. Each dwelling type was analysed on a step-by-step basis so that the effect and cost-effectiveness of each improvement measure could be examined separately.

The details of the BREDEM analysis and any recommended changes were discussed with the associations. The final specifications were then decided by the associations in conjunction with their consultants; in six of the seven projects amendments were made to the association's original specification.

3.2.2 Earlier projects

For the five earlier projects, the BREDEM analysis was carried out for the 'before' and 'after' refurbishment situations. Payback periods were also calculated to illustrate the cost-effectiveness of the work.

3.3 Criteria used when recommending energy efficiency measures

Each measure was examined in turn, including those already incorporated in the design and those proposed by BRE. This was done by comparing the estimated saving in energy costs with the cost of implementing the measure, ie the payback period. These calculations were generally carried out after the successful tender had been selected by the association.

In general, energy efficiency measures were considered to be cost-effective if they had payback periods of 10 years or less for fabric measures, and five years or less for heating-related measures (because lifespans are shorter for heating plant than for fabric).

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4.0 RESULTS

4.1 BREDEM analysis

The BREDEM analyses for both the before and after refurbishment situations are based on a fully heated dwelling with standard internal temperatures, heating patterns and occupancy patterns. The living-room temperature assumed for the properties, both before and after refurbishment, is 21°C. It is likely, however, that many of the dwellings studied in this Report were inadequately heated before refurbishment, ie to a living-room temperature below 21°C, with only parts of the dwelling heated at any time. As a result, some of the benefits of the energy efficiency measures will be taken as increased comfort, and therefore the estimates of savings in energy cost and CO_2 emission figures produced by BREDEM should be regarded as indicative only.

The results are summarised in figures 1, 2 and 3 (see pages 10 and 11), which set out the SAP ratings, estimated energy costs and estimated CO_2 emissions for the dwellings judged to be the highest and lowest rated refurbished dwelling in each project.

- 83% of the dwellings assessed achieved SAP ratings in excess of 70 after refurbishment.
- Estimated total energy costs were reduced on average by £332, to £149 per year (an average reduction of 69%).
- The average estimated reduction in annual CO_2 emissions was 4.2 tonnes (an average reduction of 56%).

The relationship of SAP rating to floor area is shown in figure 4 (page 11).

The estimated differences between the earlier and the current projects are:

- CO_2 emissions decreased by 66% for the least efficient 'current' dwelling, and by 48% for the most efficient. For the earlier projects the equivalent figures are 45% and 34% respectively.
- Energy costs for the least efficient dwelling of the current projects decreased by 60%, while savings for the most efficient dwelling amounted to 72%. In the case of the earlier projects, the equivalent figures are 73% and 65% respectively.

4.2 Recommendations for improvement to original specification

The original specification proposed by the associations generally achieved a high standard of energy efficiency. However, as may be seen from table 2 (page 12), the energy efficiency standard was generally higher for the seven current projects. This is because additional energy efficiency measures were suggested, and improved technology and materials were available compared to the earlier projects.

Table 2 summarises the main additional measures recommended for the current projects, together with the number of times the measures were recommended and the number of occasions they were included in the final specification.

4.3 Recommendations not included in the final specification

There were several reasons why the recommended improvements were not always adopted by the associations. One major reason for this was that many contracts were at an advanced stage when the BREDEM analysis was carried out and associations were understandably reluctant to delay the tender procedures. The following reasons were also given for not being able to implement measures.

- **Budgetary implications** – the budgets for the refurbishment works were generally restricted. This discouraged associations from implementing some of the recommendations, especially for the more expensive items such as low-emissivity (low-e) glazing and condensing combination boilers. However, most of the associations stated that measures that had not been adopted this time were likely to be considered for future refurbishment projects. For three of the associations the future refurbishment projects referred to included later phases of the projects described in this study.

- **Doubts about condensing combination boilers** – several associations considered that condensing combination boilers, despite their predicted running cost advantages compared to standard combination boilers, were too expensive to buy.

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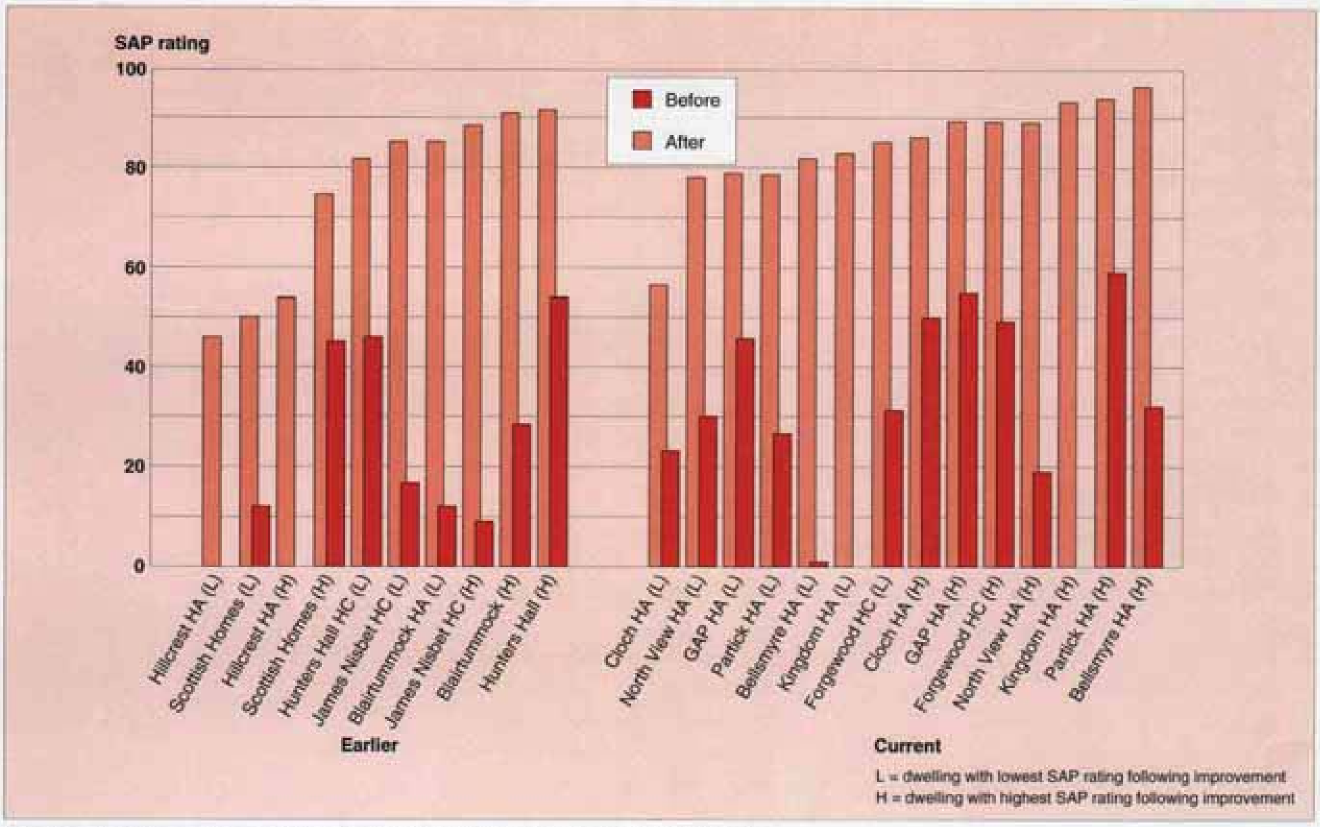

Figure 1 Estimated SAP ratings for each dwelling before and after improvement

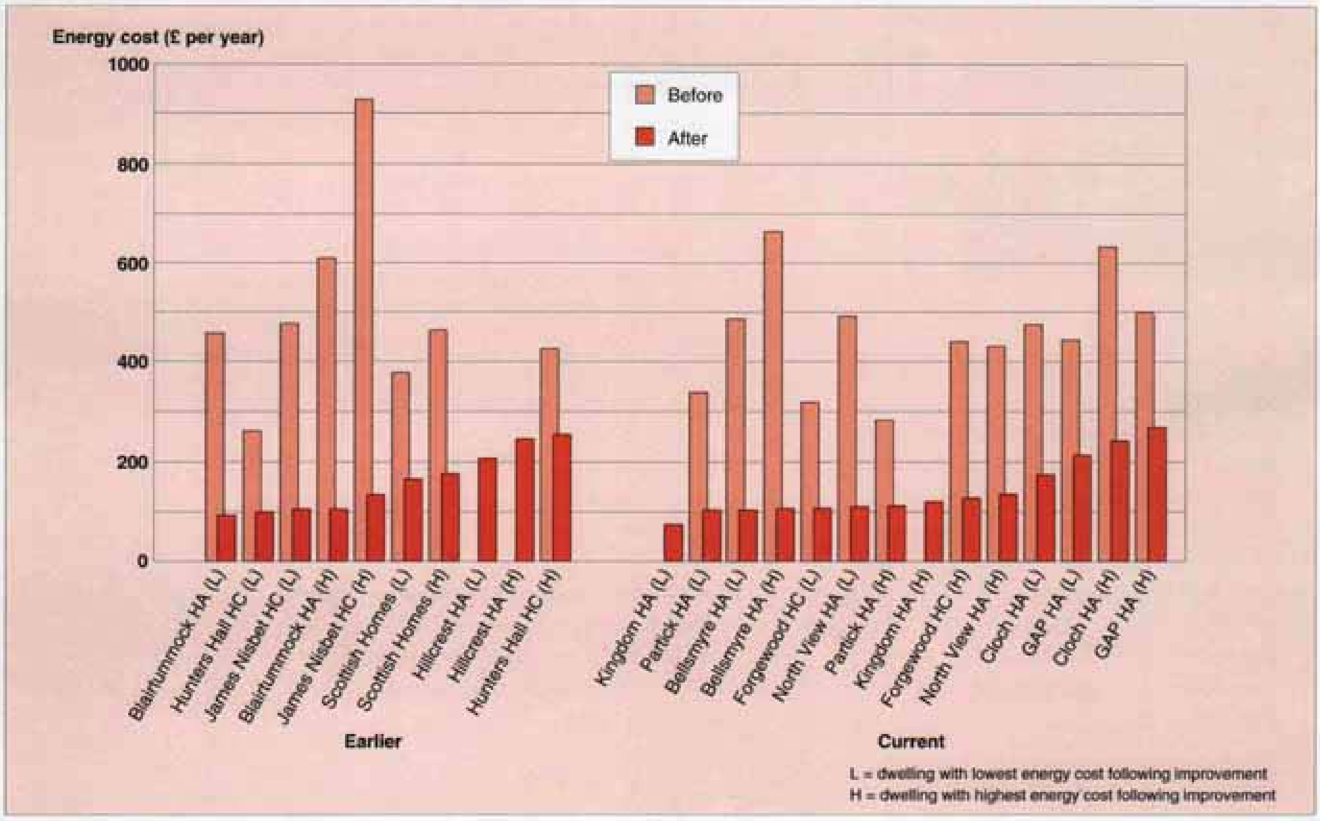

Figure 2 Estimated energy cost for each dwelling before and after improvement

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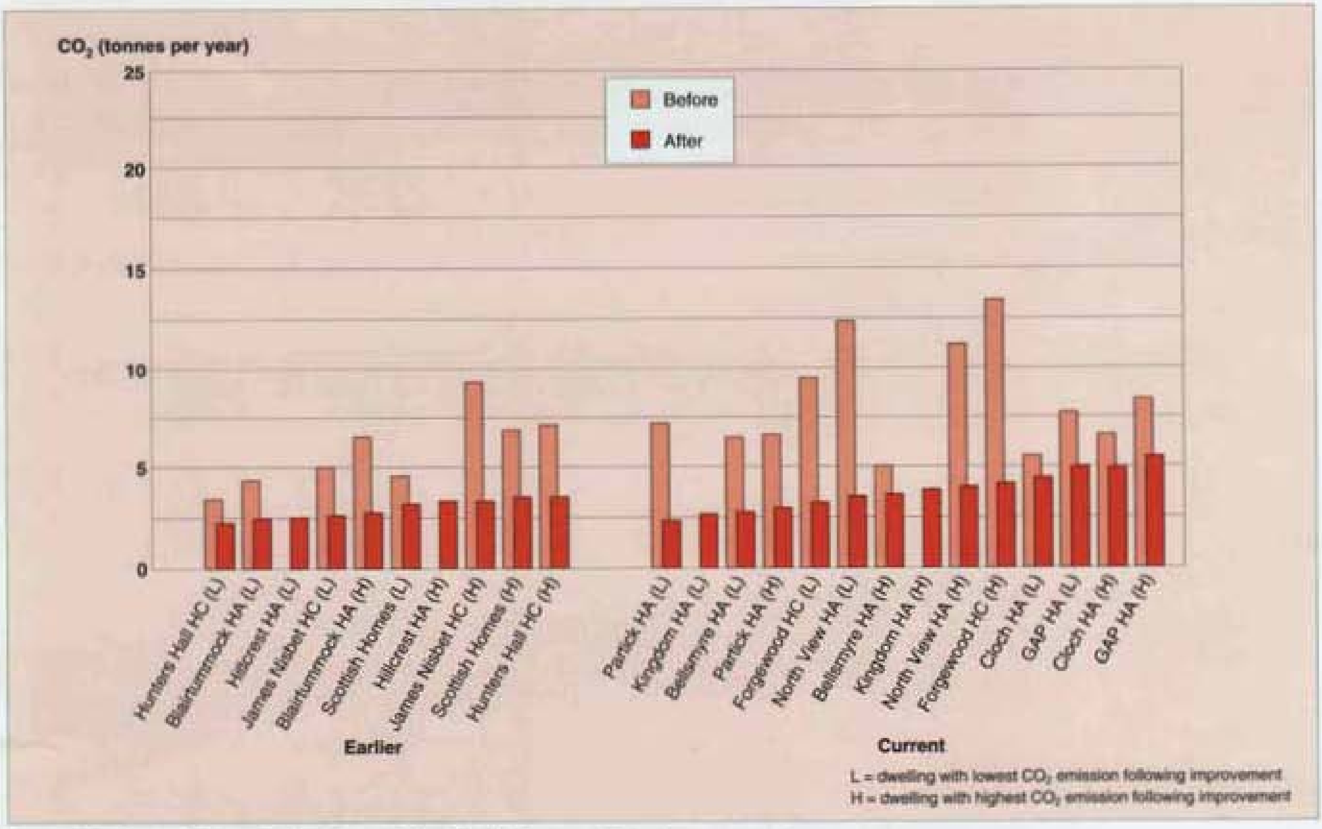
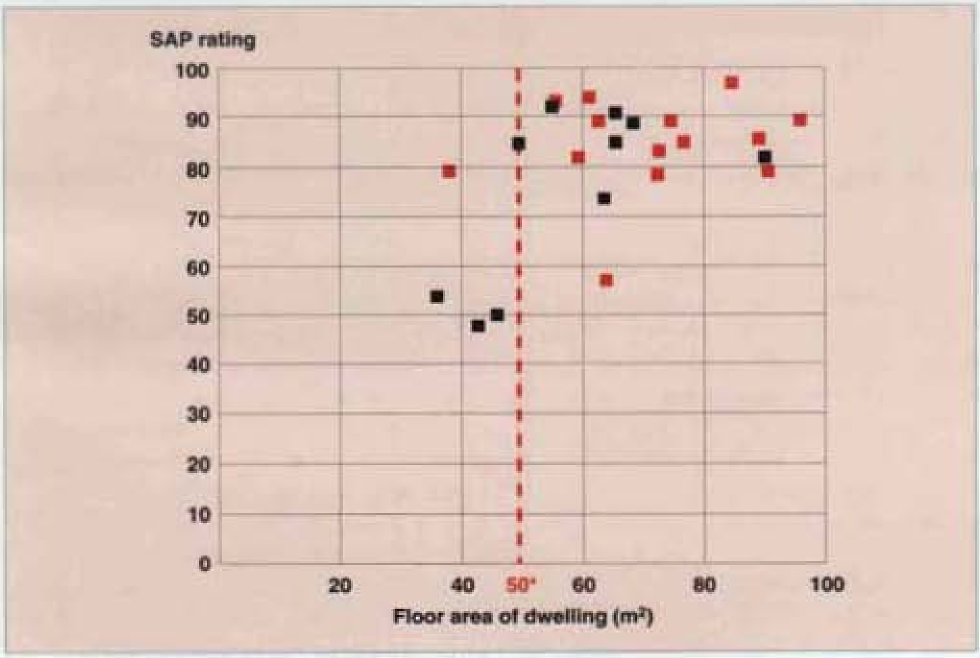


Figure 3 Estimated CO_2 emission for each dwelling before and after improvement



*It is more difficult for dwellings with a floor area of less than 50m² to achieve recommended SAP ratings (see page 20)

Figure 4 Estimated SAP ratings for individual dwellings by floor area

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Table 2 Additional energy efficiency measures recommended to associations for the seven current projects

Energy efficiency measure	Number of times recommended	Number of times included in final specification
Additional loft insulation (200 mm instead of 150 mm)	6	3
Stairhead hatch insulation	1	1
Improved floor insulation	1	0
Insulation behind dry lining	2	2
Cavity fill	3	0
Close wall and ceiling insulation	3	3
Low-emissivity glazing	4	0
Low energy lights in communal areas	2	0
Passive stack ventilation in place of extract fans	1	0
Standard combination boiler instead of conventional boiler	3	2
Condensing combination boiler instead of standard combination boiler	6	1
Improved heating controls	1	0

Condensing combination boilers were generally regarded as unproven technology with potentially high maintenance costs.

- **Boiler siting restrictions** – the policy of one association (Cloch – see case study 2) was to remain with conventional back boilers instead of combination boilers. This choice was influenced by the lack of suitable space for combination boilers in some tenement flats where combination boilers would have had to be sited in bedrooms. In addition, the extraction of gases was easy to achieve with back boilers sited in the chimney space.

- **Restrictions on full cavity fill** – one association's (Kingdom – see case study 11) refurbishment was underwritten by an NHBC warranty which, at the time of construction, excluded the full filling of cavities in Scotland.

The payback period analysis showed that a number of suggested measures were not cost-effective from an energy point of view. However, they are usually justified for other reasons (eg to reduce the risk of condensation) or when carried out in conjunction with other work.

4.4 The energy efficiency measures adopted

The associations generally undertook refurbishment work to improve the standard of the housing stock so as to provide affordable warmth for their tenants; the payback period did not appear to be the overriding criterion for selection of a particular measure. Some of the associations had a well developed specification; others relied on their architect to design the refurbishment and to select the energy efficiency measures for inclusion. The uptake of the energy efficiency measures during the refurbishment works is shown by type of building in table 3 (all twelve projects being considered).

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4.4.1 Roof insulation

After the refurbishment works all of the pitched roofs had an insulation thickness of 100-200 mm, with 150 mm being the most common thickness (five projects).

4.4.2 Insulation of external walls

All four stone-built properties were thermally improved by internal insulation; the thicknesses of the insulation being 32.5 mm, 50 mm, 75 mm and 80 mm. The insulation was either in the form of a composite board or as a quilt between timber framing.

Internal insulation using composite board was chosen for one of the two no-fines projects. The refurbishment of the other incorporated rendered external insulation.

The cross wall housing project had both rendered external insulation to the masonry walls and internal insulation to the timber infill panels.

4.4.3 Cavity wall construction

External insulation was specified to thermally upgrade the external walling with insulation thicknesses being 80 mm for one project and 60 mm

Table 3 Summary of energy efficiency measures undertaken by building type

Building type	Traditional tenement	Low-rise housing: no-fines	Low-rise housing: cross wall	Low-rise housing: cavity wall	High-rise	Conversion
Number of projects	2	2	1	4	1	2
Roof insulation	2	2	1	4	1	2
External wall insulation	0	1	1	3	1	0
Internal wall insulation	2	1	1	1	0	2
Cavity wall insulation	–	–	0	(1)	–	–
Close wall insulation	2	2	–	2	0	2
Ground floor insulation	0	2	0	1	(1)	1
Double glazing with draughtstripping	2	2	1	4	1	2
Extract fans	2	2	1	4	(1)	2
Gas heating – conventional boiler	1	0	0	0	District system	0
Gas heating – standard combination boiler	1	2	1	3*	0	0
Gas heating – condensing combination boiler	0	0	0	1	0	1
Electric heating	0	0	0	1*	0	1

Numbers in brackets indicate that the measure was in place before the refurbishment
**One project had both electric and gas heated flats*

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A close wall is one that adjoins an internal public space – usually a stairwell or a common passageway

for three projects. External rendering or cladding was used to cover the insulation. One of the four projects had cavity fill fitted at the time of original construction, but no final specification for the other three projects included cavity fill.

The high-rise block was externally insulated with 150 mm of insulation behind overcladding.

4.4.4 Close wall insulation

In nine of the 11 projects where there were closes, insulation to the close wall and ceiling was included in the refurbishment. The insulation ranged in thickness from 19 mm to 80 mm and was achieved by lining the wall on either the external close side (four projects) or the room side (five projects). In the case of tenement refurbishment, the use of external close wall lining was favoured because of the small size of the rooms.

4.4.5 Ground floor insulation

Eleven of the projects had no ground floor insulation prior to refurbishment and this measure was included in the refurbishment specification for four of the projects. These included one of the conversions where new flats were constructed behind an existing façade, and it was therefore easier to incorporate insulation of the ground floor. One other project incorporated insulation below ground floor level on the inner side of the inner leaf. The original 25 mm insulation to the ground floor of the high-rise block was not upgraded.

4.4.6 Windows

Double glazing with draughtstripping was specified in all of the projects. None of the replacement windows in the earlier projects had PVC-U frames. However, they were included in two of the seven current projects; four others included timber frames and one specified both PVC-U and timber. In this case the timber frame windows were used on the listed stone façade. One project had large areas of fixed light panels that were triple glazed.

4.4.7 Ventilation

Eleven projects included kitchen and bathroom extract fans in the final refurbishment specification. In three of these examples the fans were humidity controlled, with the others linked to the light switch. In the refurbishment of the high-rise block, window head trickle vents were installed in addition to existing extract fans.

4.4.8 Heating system

Ten of the 12 projects had gas-fired heating after refurbishment, one (where the tenants were given the choice) included both electric and gas, and one had electric heating only. Of the gas-fired systems installed, one had conventional back boilers, seven had standard combination boilers, two had condensing combination boilers, and the high-rise block had district heating.

- **Housing with central heating before refurbishment** – four of the projects had a heating system in place before refurbishment. Of these, three saw a change from electric heating to gas heating. The housing in the fourth project had a conventional gas-fired system which had been fitted six years previously. This was replaced by a combination system.

- **Housing with no central heating before refurbishment** – six of the projects relied on gas, electric and/or coal fires before the refurbishment. In all of these cases the choice was made to install gas-fired central heating.

- **Conversion projects** – these were effectively new flats within former commercial structures and therefore had no heating system prior to refurbishment. One project installed gas condensing combination boilers to the 1-, 2- and 3-bedroom flats involved. In the other conversion project the choice was made to fit electric heating to the dwellings, which were all 1-bedroom flats. The small flat size may have influenced the choice of the heating system.

4.5 Costs of energy efficiency measures

The costs of the energy efficiency measures were evaluated from the tender documents of the successful contractors. The cost-effectiveness of measures was evaluated by calculation of simple payback periods, these being the number of years in which the investment will pay for itself as a result of savings in energy. Typical payback periods are given in table 4.

Table 4 Summary of typical costs and payback periods

Construction element	Refurbishment measures	Typical cost (£/m²)	Typical payback period (years)
Pitched roofs			
no existing insulation	Add 150 mm or 200 mm insulation	2.5-4.5	1-2
50 mm existing insulation	Top up with 100 mm or 150 mm loft insulation	3-4	2
External walls			
no-fines	External insulation	65	45-75
	or insulated dry lining	20	10-15
stone	Insulated dry lining	15-30	10-15
cavity walls	External insulation	40-90	30-70
	or insulated dry lining	20	10-15
Ground floors	Lay chipboard over 100 mm insulation on existing floor	15	28
solid concrete	*or* 100 mm insulation fitted between joists on existing floor	3	6
Windows single glazing	Double glazing with draughtstripping	£ 200-300 (marginal cost)	40-100
Heating system	**Refurbishment measures**	**£/flat**	**Typical payback period (years)**
no heating	Electric storage	1000	(See case studies 11 and 12)
	or gas-fired condensing combination boiler	2000	
gas and/or electric fires	Gas-fired central heating system with conventional boilers	2100-2300	8-11
	or standard combination boilers	1500-3200	5-15

5.0 TECHNICAL RISKS AND BUILDABILITY

The following issues concerning technical risks and buildability were identified from discussions with the clerks of works. The discussions were held during visits to six of the current projects when the refurbishment works were under way.

It is appropriate to add at this point that the full value of the estimated energy savings predicted for the 12 projects described in this study are based on the refurbishment works having been carried out to a high standard of workmanship. If features such as badly installed insulation or components and poor (ie 'leaky') masonry constructions are found in practice then the actual standards of energy efficiency will be lower than predicted. Therefore the following items, as found on works in progress, illustrate particular features that require specially close attention by the people involved at the various stages of the refurbishment works.

5.1 Loft insulation

Where insulation was more than 150 mm thick, it was laid in two layers with the top layer, of 50 mm

TECHNICAL RISKS AND BUILDABILITY

in most cases, being laid cross-lapped. This is recommended by BRE to avoid thermal bridging at ceiling joists[8]. Loft hatches were also insulated, again as recommended by BRE.

5.2 Heating systems

The concept of standard combination boiler systems was well established, and the main problem with them was finding space for the boiler and the flues. This was the main reason why one association with tenement property retained conventional back boilers in their specification.

Easy access to the programmer was a problem raised by several associations, together with the fact that the controls can be difficult both to understand and operate. There was a widespread view that occupiers were unable to fully understand the operation of combination boiler heating systems. One reason for this was the perceived complexity of the programmer and the 'double stat' system where both room thermostats and thermostatic radiator valves (TRVs) are present. As a result, the full potential for energy efficiency and lower heating bills was not realised.

All of the associations issued their tenants with guidance on use of the heating systems and in some cases they followed this up with visits to check if any more assistance was required. However, there is typically a 'running-in' period for households using combination boilers for the first time, with a resultant initial reduction in energy cost savings.

It was noted that the theoretical reduction in the length of pipework as a result of replacing a conventional system by a combination system was not being achieved at one location (Birgidale Road – see case study 6). This was because the new pipework often had to follow existing routes to avoid cutting or drilling through joists and internal partitions.

5.3 Windows

In one case it was noted that the hinges of larger windows were liable to distortion during opening and closing. Larger units were also said to be less stable in high winds, making them less effective.

One association reported problems with timber windows due to the tilt and turn mechanism. This was easy to operate, but inadequate because it led to problems of water ingress and draughts. This may have been prevented by specifying a more expensive unit with a more sophisticated opening mechanism.

One form of draughtstripping around window units is to apply a mastic material to the junction of the unit and the outer leaf. The sealant usually deteriorates over time and if large gaps are present between the unit and the inner leaf (more common in refurbishment work because the window units are being fitted into existing openings) this is a ready channel for draughts. Filling any such gaps with a sealant foam was suggested as a preventive measure.

5.4 Ground floor insulation

Only four of the seven current projects included ground floor insulation. These were:

- one project where the flats were newly built behind an existing façade and insulation was therefore easier to incorporate than in a typical refurbishment
- two projects with insulation laid under the floor between joists
- one project which included insulation to the inner side of the inner leaf of the cavity wall below floor level. Dependent on the detailing present, this kind of measure is generally not as effective as the same level of insulation fitted under the floor.

No matter what method is used, attention should be paid to ensure that there are no thermal bridges at wall/floor junctions[8].

Three of the projects had no ground floor insulation, which was due largely to the difficulties of obtaining access below ground.

5.5 Multiple ownership of properties

In three projects where there was a mixture of association and private ownership there was hindrance of varying degrees to the progress of the refurbishment works. This was because of the

differing requirements of the various owners – such as different heating systems/pipework and positioning of room fires. This situation was particularly noted at the tenement property which had commercial units on the ground floor and 50% of the flats were privately owned.

6.0 TENANT PARTICIPATION

Tenant involvement is an important element of energy efficiency. This includes tenants knowing how to control and operate their heating system and, where possible, tenant involvement in the decision-making process [6,7].

6.1 Format of meetings

Five of the seven associations with current refurbishment projects accepted the opportunity to host a meeting to discuss energy efficiency, both as it applied to their project, and on a wider basis. The original reason for holding these meetings was to promote the ideas behind energy efficiency to as wide an audience as possible and to discuss the options for refurbishment investment with the tenants. The meetings varied in format and audience, depending on the association's preference, but could be regarded as having one of the following three formats.

- **Tenant meetings** – prior to the start of refurbishment works, tenants were invited by one association to learn what was planned and to discuss issues such as probable disruptions due to the works, the use and control of the new heating system, and the benefits that they would be likely to gain. The association that chose this form of meeting judged afterwards that it had been useful, but that to achieve maximum benefit it should take place reasonably near the finish date of the works (see case study 6). The reason for this is to ensure that the information given at the meeting is as fresh as possible in peoples' minds when they move into the refurbished properties. The association was particularly interested in this form of meeting, being a small locally based organisation and where the same tenants remained after the refurbishment.
- **Association Development Committee meetings** – one of the large regionally based associations chose this style of meeting. Presentations were made to the development sub-committee, which is responsible for all refurbishment and new build work undertaken by the Association. The meeting focused on:
  - the choice of energy efficiency measures which had been made by the Association for the project under consideration, and
  - choices which they could make in future refurbishment projects.
- **Meetings of Association committees where tenant representation is included** – this type of meeting included elements of both of the other types. Three associations chose this form of meeting.

All of the five meetings included discussion, to differing degrees, of the following points:

- SAP ratings, the concept of SAP, heating costs and CO_2 emissions
- the energy efficiency specification adopted by the association, other measures that had been considered but not included, and measures that could be considered for future projects
- the benefits of the refurbishment to the tenants, to the association and the environment.

6.2 Setting energy efficiency targets

The level of energy efficiency achieved by an association generally depended on either its own standard specification or the advice of the architects employed (which was particularly relevant for the smaller associations).

At all of the meetings it was suggested that the BREDEM analysis, especially the SAP rating, could be used as a means to ensure that a high level of energy efficiency could be achieved in future projects (both refurbishment and new build). Associations could set their own targets for SAP ratings, or energy costs, and ensure that, wherever possible, the architect achieved these targets.

CONCLUSIONS AND RECOMMENDATIONS

7.0 CONCLUSIONS

Most of the housing association and cooperative refurbishment projects in this study achieved a high level of energy efficiency.

- 83% of the assessed dwellings achieved SAP ratings better than 70 after refurbishment.
- Energy costs per dwelling were estimated to have reduced by an average of 69%.
- CO_2 emissions per dwelling were estimated to have reduced by 56%.

A number of energy efficiency techniques were used in the projects studied. There was, however, a reluctance to specify some of the more cost-effective energy efficiency measures, in particular condensing combination boilers. These were not widely used, not only because of their high capital cost but because they are generally viewed as unproven technology.

Most of the refurbishment projects aimed to improve the standard of the housing stock in order to provide affordable warmth for their tenants. However, the study successfully highlighted the usefulness of SAP ratings and estimated energy costs in evaluating refurbishment projects.

Tenant participation in the selection of energy efficiency measures varied with the type and size of association. Tenants in the locally based associations had the greatest influence over the options selected.

It is recognised by associations that many tenants will not gain the full benefits of having gas-fired combination boiler systems because of an initial lack of understanding of how to use the system. This is not helped by the complexity of the control systems, which elderly and infirm people, in particular, sometimes find difficult to operate.

8.0 RECOMMENDATIONS FOR REFURBISHMENT

The following guidance is intended as an aid to housing associations and their consultants in preparing the specification for refurbishment projects. The guidance is based on the results of this study. However, the recommendations are not exhaustive. In this section where a reference is made to required U-values, this should be taken to mean to the building regulations current at the time[8], or better.

Some of the points listed here may appear to be obvious. However, during the study it became clear that, while most projects were carried out to a high standard, some relatively basic potential problems had not been fully addressed.

8.1 Thermal insulation

The objective is to reduce the amount of heat lost from the dwelling as a whole by the provision of continuous all-round insulation. It is usually cost-effective to ensure that all elements (floors, walls, roofs and windows, doors and their frames) have good insulation, rather than applying very high standards of insulation to a few elements, and low standards on others.

- **Roofs** – insulate to the required U-value (typically 0.25 W/m^2K), or better; this is normally achieved with 150 mm (ideally 200 mm) of insulation. If more than 100 mm is to be used the extra thickness should be laid across the joists to reduce thermal bridging through the joists.
- **External walls** – generally the walls should be upgraded to the required U-value (typically 0.45 W/m^2K), or better, by the addition of insulation. The location of the insulation will depend on the type of construction. It is preferable for the insulation to be as near to the outside of the structure as possible. For no-fines and cavity wall constructions, it is normal to provide an insulated overcladding system. For high-rise blocks, a rain screen overcladding system which incorporates insulation is a standard option. For other situations such as traditional tenements and other stone-faced buildings, it is appropriate to insulate on the inside face of the wall, eg using insulation-backed plasterboard.
- **Exposed floors** – where practicable, ground floors or any exposed floors should be insulated to the required U-value (typically 0.45 W/m^2K), or better, normally by underfloor insulation. Where this is not practicable it may be possible to provide vertical insulation from the floor to below ground level on the inside of the inner leaf, or to lay insulation under ground around the building's perimeter.

RECOMMENDATIONS

- **Semi-exposed walls and floors** – care should be taken to ensure that areas linked to stairwells or other unheated areas are adequately insulated.
- **Windows** – all units should be double glazed. Care has to be taken, when specifying or approving a supplier, to ensure easy operation and good performance. Low-e glass should be considered.
- **Thermal bridging** – there are many technical risks associated with the presence of thermal bridges, such as condensation and increased heat losses. The detailing of all junctions between elements and areas of different construction requires attention to ensure that thermal bridges are avoided. Good practice is given in comprehensive guidance prepared by BRE[5].
- **Workmanship and site supervision** – with well insulated housing, areas of poor construction can result in significant changes to U-values. This in turn may result in poorer than expected thermal performance. Therefore site inspection staff have to be aware of the problems that can result from poor workmanship.

8.2 Space and water heating

An energy efficient heating system should be selected. There are, however, other requirements that should be considered. The system selected must be correctly sized to warm up the dwelling from cold within a reasonable time and therefore the insulation standard of the dwelling must also be taken into account. The system should be reliable and easy to maintain, with effective controls that are understood by tenants[7]. Associations should also ensure that tenants know how to heat their homes effectively[6,7].

Heat loss from the system must be minimised, eg by insulation of hot water pipes and tanks.

8.3 Ventilation

Ensure that there is adequate controlled ventilation to maintain a healthy environment without unnecessary loss of heat. Extract fans, preferably with humidistat controls, should be fitted to kitchens and bathrooms.

Unplanned ventilation (draughts) can cause problems and it is worth considering limiting unwanted ventilation losses by reducing air leakage around openings and through the building fabric. Areas to check, both at the design stage and during site supervision, include service runs, joints between elements (eg floor/wall) and around doors and windows. Windows should be draughtstripped.

Tenants should be made aware of the need for adequate ventilation, how to prevent condensation, and the importance and use of extract fans[6].

8.4 Design for solar gain

Although there is generally limited scope for refurbishment designs to incorporate solar gain, opportunities may exist, depending on the type of housing concerned.

Where window area exceeds 15-20% of the floor area it may be possible to change the fenestration by changing the size of windows. Larger windows should be used on south-facing elevations and smaller windows on north-facing elevations.

It might be possible to change the layout of a dwelling by moving living spaces to the south elevation.

Depending on the orientation of existing balconies, semi-enclosed areas can be fully enclosed with glazing to provide a buffer zone.

8.5 Integrated design

All of the above considerations must be examined individually. However, to be successful, energy efficient refurbishment must be designed so that insulation, heating and ventilation all work together. With adequate temperature and ventilation levels, an integrated design maximises cost-effectiveness in construction and minimises fuel costs. For example, improving the insulation standard can influence the choice of the heating system required because the addition of insulation reduces both the energy required and the cost to heat to the same level[6].

RECOMMENDATIONS

8.6 Setting an energy target

8.6.1 The SAP method

For associations to achieve affordable heating in refurbishment projects they have to be aware of the thermal performance of the dwellings. One method by which this can be done is with the Government's Standard Assessment Procedure (SAP) for home energy rating. SAP energy ratings provide a simple but reliable indicator of the efficiency of energy use for space and water heating in a dwelling[2].

Homes are assessed on a scale of 1 to 100; the higher the score, the more efficient the home. Computer software which generates SAP ratings can be used to estimate the annual energy (ie space and water heating) costs of dwellings.

8.6.2 Setting a target SAP rating

Setting a target for existing properties is not straightforward, partly because properties with the same level of accommodation can vary widely in their floor area. This is important because SAP ratings are based on fuel costs per square metre of floor area. This means that where two properties have the same number of bedrooms, but different floor areas, the larger property needs to achieve a higher SAP rating than the smaller property if it is to cost the same to heat. In practice, it has been found that it is easier for larger properties to achieve a higher SAP rating than smaller properties, assuming they both have the same type of heating system and level of insulation.

Floor area is not the only variable in setting a target SAP rating. It has to be borne in mind that because SAP ratings apply to individual dwelling types there will be a range of SAP ratings for any group of houses or flats. In addition, refurbishment projects in colder regions may need a higher standard to be set for the same level of affordable warmth. This is because SAP assumes an average climate for the UK.

The comparison of floor areas and SAP ratings (figure 4, page 11) for the refurbished dwellings enables recommendations to be made concerning SAP ratings that may be achieved by refurbishment works. SAP ratings vary according to the size and position of dwellings, so it is recommended that both a minimum and a mean SAP rating target are set for the designers, when associations are setting their energy efficiency policy.

For dwellings over 50 m² floor area it is suggested that the following SAP ratings should be targeted:

- minimum SAP rating of 70 for each dwelling
- mean SAP rating of 75 for all dwellings in a scheme.

These should be taken as guidance only, because the target SAP ratings for each individual refurbishment project will have to be considered, depending on issues such as association policy, type of stock, and funding available.

It is easier for larger properties to achieve a given SAP rating, so it is likely that it will be difficult for smaller dwellings (those of under 50 m² floor area are suggested by figure 4) to achieve the values of 70 and 75 recommended here. A lower SAP rating may, therefore, be inevitable for smaller dwellings.

APPENDICES

Appendix 1: Addresses of participating organisations

Housing Associations and Cooperatives

Bellsmyre Housing Association
3B Stoneyflatt Avenue, Dumbarton G82 3JQ

Blairtummock Housing Association
3A Boyndie Street, Glasgow G34 9JQ

Cloch Housing Association
6 Regent Street, Greenock PA15 4PL

Forgewood Housing Co-operative
66 Kylemore Crescent
Motherwell ML1 3XA

GAP Housing Association
14 Woodside Crescent, Glasgow G3 7UL

Hunters Hall Housing Co-operative
77 Niddrie House Drive
Edinburgh EH16 4TR

Hillcrest Housing Association
4 South Ward Road, Dundee DD1 1PN

James Nisbet Housing Co-operative
98 James Nisbet Street, Glasgow G21 2LH

Kingdom Housing Association
Saltire Centre, Pentland Court
Glenrothes, Fife KY6 2DA

North View Housing Association
31B Birgidale Road, Glasgow G45 9LZ

Partick Housing Association
10 Mansfield Square, Glasgow G11 5QP

Scottish Homes (see below)

Organisations involved in the research

ASSIST Architects
Station Terrace, 100 Kerr Street
Bridgeton, Glasgow G40 2PQ
Tel 0141 554 0505
Fax 0141 554 6112

Building Research Establishment
Scottish Laboratory, Kelvin Road
East Kilbride, G75 0RZ
Tel 01355 233001. Fax 01355 241895

BRECSU
BRE, Garston, Watford WD2 7JR
Tel 01923 664258
Fax 01923 664787

Scottish Homes
Strategy and Performance
Thistle House, 91 Haymarket Terrace
Edinburgh EH12 5HA
Tel 0131 313 0044. Fax 0131 313 2680

Appendix 2:

Other sources of advice

Energy Action Scotland
21 West Nile Street, Glasgow G1 2PS
Tel 0141 226 3064
Fax 0141 221 2788

Energy Advice Design Scheme
Royal Incorporation of Architects in Scotland
15 Rutland Square, Edinburgh EH1 2BE
Tel 0131 228 4414
Fax 0131 228 2188

Scottish Federation of Housing Associations
38 York Place, Edinburgh EH1 3HU
Tel 0131 556 5777
Fax 0131 557 6028

Scottish Office Development Department
Construction and Building Control Group
Victoria Quay, Edinburgh EH6 6QQ
Tel 0131 556 8400
Fax 0131 244 7454

Tenant Participation Advisory Service
20 & 24 St Andrew's Street
Glasgow
G1 5PD
Tel 0141 552 3633
Fax 0141 552 0073

REFERENCES

REFERENCES

[1] **Department of the Environment.** Review and development of energy efficient refurbishment standards for housing associations. General Information Report 32. DOE, London, 1995.

[2] **Department of the Environment.** The Government's Standard Assessment Procedure for energy rating of dwellings. DOE, London, 1995.

[3] **Department of the Environment.** This Common Inheritance. DOE, London, 1990.

[4] **Scottish Federation of Housing Associations.** Design and Construction Standards, SFHA Briefing Paper No 18, 1995.

[5] **Building Research Establishment.** Thermal insulation: avoiding risks. BRE report *BR*262. BRE, Garston, 1994.

[6] **Department of the Environment.** Energy efficient refurbishment of existing housing – a refurbishment guide for housing associations and landlords. Good Practice Guide 155. DOE, London, 1995.

[7] **Department of the Environment.** Providing energy advice to householders – a guide for local authorities and housing associations. Good Practice Guide 208. DOE, London, 1996.

[8] **The Scottish Office.** The Building Standards (Scotland) Regulations 1990, Technical Standards Part J Conservation of fuel and power.

Department of the Environment Energy Efficiency Best Practice programme documents (including references 1-3, 6 and 7) are available from BRECSU (see back page for contact details).

Building Research Establishment documents are available from BRE's publisher, CRC Publications. Tel 01923 664444.

1

DUMBARTON ROAD, GLASGOW
PARTICK HOUSING ASSOCIATION

Partick is a locally based housing association with over 1200 properties in a well established district approximately three miles from Glasgow city centre. The 4-storey traditional tenement at Dumbarton Road was built at the turn of the century, and over the past 17 years Partick Housing Association has acquired flats in the block from Glasgow District Council and private owners. The refurbishment work included the remodelling of the original 18 flats into 12, six of which are owned by the Association. The tender cost for the 12 flats was £471 000, equivalent to £39 000 per unit. The refurbishment of the five commercial units on the ground floor was additional to this.

The block has solid sandstone external walls, a pitched roof and timber/floating floor construction. Heating was by electric and coal fires.

Energy efficiency specification

The project was the sixty-eighth refurbishment undertaken by the Association and the original specification, developed in conjunction with John Gilbert Architects, was high in terms of energy efficiency. However, the Association specified gas heating with conventional boilers; after consultation with the Building Research Establishment (BRE), combination boilers were included which proved to be a financial saving to the Association. Two other items were suggested by BRE for inclusion in the specification but not incorporated. These were:

- low emissivity (low-e) glazing – not included due to cost restrictions
- condensing combination boilers – not included due to the capital cost involved and uncertainty over their use and maintenance.

This page forms part of Good Practice General Information Report 46 (GIR 46), 'Energy efficiency in Scottish Housing Association refurbishment projects', produced by BRECSU as part of the Department of the Environment's Energy Efficiency Best Practice programme. For further information on buildings-related topics contact: Enquiries Bureau, BRECSU, BRE, Garston, Watford, WD2 7JR Tel 01923 664258 Fax 01923 664787 E-mail brecsuenq@bre.co.uk

DUMBARTON ROAD, GLASGOW
PARTICK HOUSING ASSOCIATION

1

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- loft space insulation, 1 year
- insulation to external walls, 10 to 15 years
- insulation of close walls, 20 years
- double glazing, 50 years
- installation of gas-fired central heating with combination boilers, 40 to 50 years
- whole package, 25 to 40 years.

Estimated payback periods for those measures not included in final specification are:

- low-e double glazing, 50 years
- installation of gas-fired central heating with condensing combination boilers, 25 to 30 years

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Pitched roof	Uninsulated	150 mm mineral fibre insulation laid between joists, 60 mm across joists
External walls	600 mm sandstone	75 mm semi-rigid mineral fibre insulation boards and 12.7 mm plasterboard fitted internally
Close walls	Uninsulated	50 mm glass wool behind 12.5 mm wallboard
Windows	Timber framed single glazing	Replacement timber frame windows with double glazing (11 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Draughtstripped windows, bathroom and kitchen extract fans (linked to light switch)
Heating	Coal and electric fires	Gas-fired central heating with combination boiler (balanced flue), programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From combination boiler system

Table 1 Energy efficiency measures

Item	Top floor 1-bed mid-flat		First floor 2-bed gable flat	
	Before	After	Before	After
SAP rating	27	79	59	94
Annual space and water heating costs	£338	£101	£279	£114
CO_2 emissions (tonnes/year)	7.2	2.3	6.6	2.9

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Energy efficiency measures

The measures included in the final specification were:

- mineral fibre loft insulation
- internal insulation and plasterboard to external walls
- insulation to close walls
- replacement timber framed double glazing
- extract fans to bathroom and kitchen
- full gas-fired central heating with combination boiler.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the flat types estimated to have the highest and the lowest SAP ratings after refurbishment. The analysis showed that excellent SAP ratings were achieved. Annual space and water heating costs were estimated to have reduced by 70% for the top floor 1-bed flat and 59% for the first floor 2-bed gable flat. Corresponding CO_2 emissions are estimated to have decreased by 68% and 56% respectively.

Buildability issues

The different ownership not only of the flats, but of the commercial units, caused delays during the refurbishment works. There was concern that the internal brickwork walls running the height of the building might become unsafe as a result of the building works. When the walls were being stripped only one side of the wall was exposed at a time to avoid problems with the mortar, which was thought to be poor. This was then plastered to hold the mortar in place, before the other side was stripped and plastered. The walls were also extended into the roof space and strapped to the joists to make them more secure.

Over time the sandstone external walls had tended to move outwards. This was resolved by fixing the walls to both the floors and inner walls. Potential problems where movement between the inner walls and the external walls might lead to cracking of plaster were addressed by plastering over metal lath fixed across the junctions.

2

BELVILLE STREET AND BAWHIRLEY ROAD, GREENOCK CLOCH HOUSING ASSOCIATION

Cloch is a locally based housing association with about 350 properties. The full refurbishment of the 4-storey tenements at Belville Street and Bawhirley Road was carried out in 1996. From early 1995 Cloch had acquired from various private owners a mixture of 1-, 2- and 3-bedroom flats in the blocks. During the refurbishment some remodelling of the blocks was undertaken which reduced the number of flats from 51 to 48. Twenty-two of the flats remain privately owned. The tender cost of the refurbishment was £1.8 million, equivalent to £37 500 per flat.

External walls are solid sandstone and the ground floor is of solid construction. Heating was by gas and electric fires.

Energy efficiency specification

Previously, Cloch had refurbished 13 other tenement blocks and, in addition to a 'green' policy, has developed its own general specification for tenement refurbishment which Hypostyle Architects used as a basis for its designs. The specification was already high in terms of energy efficiency, but after consultation with the Building Research Establishment (BRE) it was modified to reflect greater energy efficiency.

Modifications included insulation between the plasterboard and external walling. This was incorporated into the specification following a condensation risk analysis by BRE which indicated that condensation was unlikely to occur within the construction if a vapour control layer was used. The Association's general specification was subsequently upgraded as a result of the suggested modifications.

One measure suggested by BRE was not incorporated into the final specification for the Association-owned flats: combination boilers were not used in place of the back boilers because of the Association's policy that new heating systems for

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BELVILLE STREET AND BAWHIRLEY ROAD, GREENOCK
CLOCH HOUSING ASSOCIATION

2

The range of estimated payback periods* for the main energy efficiency measures, taking into account the different flat types present, are:

- insulation of loft spaces, 1 year
- internal insulation of external walls, 10 to 15 years
- close wall insulation, 10 years
- double glazing, 40 to 50 years
- installation of gas-fired central heating with back boiler, 8 to 10 years
- installation of gas-fired central heating with combination boilers, 8 to 12 years
- whole package, 15 to 20 years (with back boiler), 20 years (with combination boiler).

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore, payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated	150 mm mineral wool loft insulation between joists, 50 mm laid over joists
External Walls	600 mm sandstone	Plaster removed. External wall – 50 mm expanded polystyrene insulation – plasterboard
Close walls	Uninsulated	Composite board comprising 12.5 mm wallboard and 19 mm extruded polystyrene fitted internally
Windows	Single glazing	Replacement timber windows with double glazing (22 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Draughtstripped windows, bathroom and kitchen extract fans (linked to light switch)
Heating	Gas and electric fires	Gas fires, gas-fired central heating from back boiler, programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From back boiler, 135 litre hot water tank with 80 mm factory-applied insulation

Table 1 Energy efficiency measures

Item	Second floor 3-bed mid-flat		Ground floor 2-bed gable flat	
	Before	After	Before	After
SAP rating	50	86	23	57
Annual space and water heating costs	£477	£173	£631	£241
CO_2 emissions (tonnes/year)	5.5	4.4	6.7	4.9

Note: Above figures are for flats with back boiler, the substitution of combination boilers in place of back boilers would have a minimal effect on these figures, including that the SAP ratings would increase by two points.

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

tenement flats should be back boilers. This is based on the Association's experience that in some tenement flats it can be difficult to find suitable external wall space for siting a combination boiler and that installing the flue of a back boiler is easier to achieve in the limited space available. The private owners were given the choice of boiler type and 16 of the 22 chose combination boilers. This was despite the fact that in most cases the boilers had to be fitted in bedrooms because of the lack of space. This problem is not found in all tenements and the Association indicated that its policy on the specification of combination boilers may change in future.

Energy efficiency measures

The measures included in the final specification were:

- mineral wool loft insulation
- internal insulation and plasterboard to external walls
- insulation to close walls and ceiling
- replacement timber frame double glazing
- kitchen and bathroom extract fans
- draughtstripping front doors of flats
- full gas-fired central heating with back boiler (Association-owned flats)
- full gas-fired central heating with combination boiler (privately owned flats).

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results from the two flat types estimated to have the highest and the lowest SAP ratings after refurbishment. The analysis showed that good SAP ratings were achieved. Annual space and water heating costs were estimated to have reduced by 64% for the second floor 3-bed flat and 62% for the ground floor 2-bed flat. Corresponding CO_2 emissions were estimated to have reduced by 20% and 27% respectively.

3

MERKINS AVENUE, DUMBARTON
BELLSMYRE HOUSING ASSOCIATION

This was the second phase of ongoing refurbishment work carried out by Bellsmyre Housing Association, which owns about 150 properties in a housing estate on the outskirts of Dumbarton. The housing described in this study was built in 1956 and contains 42 flats entered by seven closes. The Association acquired the properties from Scottish Homes in 1992. The tender costs of the refurbishment work was £1.55 million, representing £37 000 per unit.

The construction comprises external walls of no-fines concrete, pitched roofs and solid concrete floors. Heating was by electric fires.

Energy efficiency specification

The refurbishment included some remodelling of the blocks with the partial removal of balconies on the front elevation, and the extension of entrance areas and the bedrooms above on the rear elevation. The design by Michael & Sue Thornley Architects was to a particularly high standard of energy efficiency. Because of this, and the advanced stage at which the Building Research Establishment (BRE) became involved, three additional measures suggested by BRE were not adopted. These were: additional 50 mm loft insulation, low emissivity (low-e) double glazing and the use of a condensing combination boiler.

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MERKINS AVENUE, DUMBARTON
BELLSMYRE HOUSING ASSOCIATION

3

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- 150 mm loft space insulation, 1 year
- insulation to close walls, 10 to 15 years
- double glazing and balcony, 130 to 150 years
- external insulation, 45 to 75 years
- ground floor insulation, 30 years
- installation of gas-fired central heating with combination boiler, 4 to 5 years
- whole package, 20 to 35 years.

Estimated payback periods for those measures not included in final specification are:

- additional 50 mm loft insulation, 1 year
- low-e double glazing, 110 to 130 years
- installation of gas-fired central heating with condensing combination boiler 4 to 6 years.

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated loft	150 mm mineral fibre
External walls	300 mm no-fines concrete (250 mm on third floor)	Render (6 mm) and 60 mm expanded polystyrene to existing walls. 50 mm cavity and plasterboard (12.5 mm) internally
Close walls	Uninsulated	9.5 mm plasterboard and 30 mm polyurethane composite board to existing wall
Windows	Single glazing	Replacement timber frame double glazing (12 mm gap) and draughtstripping
Ground floor	Uninsulated	18 mm chipboard over 100 mm insulation
Ventilation	Uncontrolled	Draughtstripped windows, bathroom and kitchen extract fans (on a time switch)
Heating	Electric fires	Gas-fired central heating with combination boiler (fan assisted flue), programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From combination boiler system

Table 1 Energy efficiency measures

Item	Top floor 1-bed flat		First floor 3-bed flat	
	Before	After	Before	After
SAP rating	1	82	32	97
Annual space and water heating costs	£665	£105	£487	£102
CO_2 emissions (tonnes/year)	6.5	2.7	5.0	3.7

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Energy efficiency measures

The measures included in the final specification were:

- mineral fibre loft insulation
- rendered polystyrene external insulation
- insulation to close walls
- enclosure of balconies
- ground floor insulation
- replacement timber frame double glazing
- extract fans in kitchen and bathroom
- full gas-fired central heating with combination boiler.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the two flat types estimated to have the highest and the lowest SAP ratings after refurbishment. The analysis showed that excellent SAP ratings were achieved, above those which could be typically expected for refurbished property. Annual space and water heating costs were estimated to reduce by 84% for the top floor 1-bed flat and 79% for the first floor 3-bed flat. Corresponding CO_2 emissions were estimated to have reduced by 58% and 26% respectively.

Tenant consultation

At a meeting with the Association's development committee it was clear that the tenants were very pleased with the refurbished housing, but that the high standard had been achieved not through the Association's own knowledge but because an architect had been employed who was experienced in refurbishment. However, for future refurbishment projects the Committee is likely to use the SAP energy rating as a design tool. This will include asking the architect to achieve a specified minimum SAP energy rating value.

4

FIFE DRIVE, MOTHERWELL
FORGEWOOD HOUSING CO-OPERATIVE

Forgewood Housing Co-operative has about 220 properties within the Forgewood district, close to the centre of Motherwell. The 1950s-built housing described in this study comprises five 3-storey blocks originally containing 42 flats which, after remodelling, were reduced to 40. Forgewood acquired the housing from Motherwell District Council in 1994. The refurbishment took place in 1996 at a tender cost of £1.5 million; equivalent to £36 700 per unit.

The construction comprises no-fines concrete external walls, pitched roofs and concrete floors. Heating was by gas and coal fires.

Energy efficiency specification

This was the third phase of refurbishment work carried out by the Co-operative and the specification by ARM Architects was to a high standard of energy efficiency. However, after consultation with the Building Research Establishment (BRE), the specification was amended to reflect greater energy efficiency by the addition of close ceiling insulation and an extra 50 mm loft insulation.

Two other measures suggested by BRE – the use of low-emissivity (low-e) double glazing and condensing combination boilers – were not

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FIFE DRIVE, MOTHERWELL
FORGEWOOD HOUSING CO-OPERATIVE

4

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- insulation of loft spaces, 2 years
- internal insulation of external walls, 10 to 15 years
- double glazing, 90 to 130 years
- close wall and ceiling insulation, 35 to 60 years
- ground floor insulation, 5 years
- installation of gas-fired central heating with combination boiler, 10 to 15 years
- whole package, 20 to 25 years.

Estimated payback periods for those measures not included in final specification are:

- low-e double glazing, 80 to 130 years
- installation of gas-fired central heating with condensing combination boiler, 10 to 15 years.

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated	150 mm glass fibre loft insulation between joists, 50 mm across joists
External walls	Rendered 300 mm no-fines concrete	External render repaired with 8 mm added to the existing 25 mm. Composite insulation board comprising 10 mm plasterboard and 35 mm extruded polystyrene insulation fitted internally
Close walls and ceiling	Uninsulated	Composite insulation board comprising 10 mm plasterboard and 35 mm extruded polystyrene insulation fitted internally
Ground floor	Uninsulated	100 mm mineral wool insulation laid under floor between joists. Fixed to joists
Windows	Single glazing	Replacement PVC-U windows with double glazing (12 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Draughtstripped windows, bathroom and kitchen extract fans (linked to light switch)
Heating	Gas and coal fires	Gas fires, gas-fired central heating with combination boiler (balanced flue), programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From combination boiler system

Table 1 Energy efficiency measures

Item	Top floor 3-bed flat		First floor 2-bed flat	
	Before	After	Before	After
SAP rating	31	85	49	89
Annual space and water heating costs	£441	£127	£317	£108
CO_2 emissions (tonnes/year)	16.1	4.1	9.5	3.2

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

incorporated into the final specification. This was primarily due to cost restrictions.

Energy efficiency measures

The measures included in the final specification were:

- glass fibre loft insulation
- internal insulation to external walls
- insulation to close walls and ceiling
- ground floor insulation
- replacement PVC-U double glazing
- extract fans to kitchen and bathroom
- full gas-fired central heating with combination boiler.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the two flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis shows that excellent SAP ratings were achieved. Annual space and water heating costs were estimated to reduce by 71% for the top floor flat and 66% for the first floor flat, with corresponding CO_2 emissions estimated to have reduced by 75% and 66% respectively.

5

MULL AND IONA PHASE 1, AIRDRIE
GAP HOUSING ASSOCIATION

GAP Housing Association has about 2000 properties throughout west central Scotland. The 2-storey terraced housing described in this case study comprises 67 3-bedroom houses built in the late 1960s. GAP acquired the properties from Monklands District Council in 1995. The tender cost of the refurbishment work was £2.44 million, representing £36 400 per house.

The houses were built with a cross wall type construction. The single aspect terraces (ie windows on one elevation only) have gable, party and front walls of traditional cavity construction; rear walls have timber infill panels and glazed areas. The dual aspect housing is similar, but with a mixture of cavity wall and infill panels at the front. All the houses had flat roofs and solid concrete floors. They already had gas-fired central heating and double glazing, both installed during previous refurbishment work in 1990.

Energy efficiency specification

The Association has extensive experience of refurbishment and the specification, by ARM Architects, was high in energy efficiency terms. However, after consultation with the Building Research Establishment (BRE), improvements were made to the specification to reflect greater energy efficiency. The changes included replacement of the existing gas-fired central heating (conventional boilers) with a gas-fired combination boiler system. The Association considered specifying condensing combination boilers as the replacement system but ruled this out due to the greater capital cost and limited experience of their use.

Three other measures suggested by BRE were not undertaken on cost grounds: additional 50 mm loft insulation, cavity fill, and floor edge insulation with expanded polystyrene at ground level around the perimeter of the terraces. These measures were

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MULL AND IONA PHASE 1, AIRDRIE GAP HOUSING ASSOCIATION

The range of estimated payback periods*, taking into account the different house types present, for the main energy efficiency measures are:

- insulation of loft spaces, 1 to 2 years
- external insulation, 10 to 50 years
- installation of gas-fired central heating with combination boilers, 30 to 140 years**
- internal insulation, 2 to 3 years
- double glazing, 60-plus years*
- whole package, 25 to 35 years.

* This is only a small cost saving and is due only to reduction in the window area. This is because double glazing was present before and after refurbishment.

** There is only a small cost saving because an efficient heating system was present before and after refurbishment.

Estimated payback periods for those measures not included in final specification are:

- additional 50 mm loft insulation, 2 to 3 years
- cavity fill in addition to external insulation, 30 to 40 years
- floor edge insulation, 45 to 50 years
- installation of gas-fired central heating with condensing combination boiler, 15 to 20 years.

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project. Because the floor, wall and roof areas all changed as a result of the refurbishment, the payback periods have been calculated relative to the new dwelling shapes.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated flat roof	New pitched roof erected. 150 mm mineral wool loft insulation between joists
External walls	103 mm brick – 50 mm cavity – 75 mm concrete block. 100 mm timber infill panels	60 mm expanded polystyrene insulation with 25 mm external render to existing walls. 100 mm mineral wool insulation behind new internal lining
Windows	Double glazing % of wall glazed: single aspect – 11% dual aspect – 14%	Replacement timber windows with double glazing (12 mm air gap) and draughtstripping % of wall glazed: single aspect – 9% dual aspect – 12%
Ventilation	Draughtstripped windows, bathroom and kitchen extract fans	Draughtstripped windows, new humidity controlled extract fans
Heating	Gas-fired central heating with conventional boilers	Gas-fired central heating with combination boiler (balanced flue), programmer and TRVs
Hot water	Electric immersion heaters	From combination boiler system

Table 1 Energy efficiency measures

Item	Single aspect end terrace		Dual aspect mid-terrace	
	Before	After	Before	After
SAP rating	46	79	55	89
Annual space and water heating costs	£500	£263	£442	£216
CO_2 emissions (tonnes/year)	8.3	5.5	7.7	4.9

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

not incorporated largely because of cost but may be considered for the remaining phases.

Energy efficiency measures

The measures included in the final specification were:

- pitched roof erected over existing flat roof with mineral wool loft insulation
- rendered external insulation
- internal insulation to timber walls
- replacement timber frame double glazing
- reduction in glazed area
- replacement extract fans to kitchen and bathroom
- full gas-fired central heating with combination boiler.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the house types before and after refurbishment. Table 2 gives the results for the two house types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis shows that, largely because of the existing double glazing and central heating, the SAP ratings before refurbishment were reasonable. As a result of the refurbishment, excellent SAP ratings were achieved. Annual space and water heating costs were estimated to reduce by 47% for the single aspect end terrace and 39% for the duel aspect mid-terrace houses. Corresponding CO_2 emissions are estimated to have reduced by 34% and 26% respectively.

Buildability issues

The theoretical saving in the amount of pipework as a result of replacing a conventional boiler system with a combination system was not wholly achieved. This was because the specified or best route for new pipework to be laid was sometimes not possible because it was crossed by joists. To prevent the removal and cutting of joists, therefore, the pipework often followed existing longer routes.

The refurbishment of the 375 houses which make up Mull and Iona was being carried out in a rolling programme over a four to five year period. As a result, opportunities were taken by the clerk of works to learn from earlier parts of the work and introduce improvements to detailing and the use of more suitable products, eg make of window unit.

6

BIRGIDALE ROAD, CASTLEMILK, GLASGOW
NORTH VIEW HOUSING ASSOCIATION

North View is a locally based housing association with about 130 properties in the large housing estate of Castlemilk on the southern edge of Glasgow. This case study describes four stairs of a terrace of 3-storey housing built in the mid-1950s and providing a total of 28 3-bedroom flats. North View acquired the properties from Scottish Homes in 1993. The tender cost of the refurbishment work was £852 000, equivalent to £30 400 per flat.

The construction comprises external brick-cavity-block walls, pitched roofs and timber floors. Heating was by coal and electric fires.

Energy efficiency specification

The project was the second phase of the planned works. The architects were The Gray Aitken Partnership who were also employed for the first phase. The specification was already high in terms of energy efficiency. Although the contract price was being negotiated downwards the specification was modified, after consultation with the Building Research Establishment (BRE), to include close wall insulation at little extra cost. The other measures suggested by BRE were: additional 50 mm of loft insulation, cavity fill, low-emissivity (low-e) glazing and condensing combination boilers. None of these measures were incorporated into the final specification because of budget restraints.

Energy efficiency measures

The measures included in the final specification were:

- mineral wool loft insulation
- external insulation (either rendered or clad with brick) to brick outer leaf.
- insulation to close walls
- below ground floor insulation on inner leaf of cavity wall
- replacement PVC-U double glazing
- kitchen and bathroom extract fans
- full gas-fired central heating with combination boilers.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats as they were before and after refurbishment. Table 2 gives the results from the two flat types estimated to have the highest and the lowest SAP ratings after refurbishment. The analysis showed that excellent SAP ratings were achieved. Annual space and water heating costs were estimated to reduce by 77% for the top floor flat and 68% for the ground floor flat; the corresponding reductions in CO_2 emissions were estimated at 76% and 67% respectively.

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BIRGIDALE ROAD, CASTLEMILK, GLASGOW
NORTH VIEW HOUSING ASSOCIATION

6

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- insulation of loft spaces, 2 years
- external insulation with rendering, 60 to 150 years
- external insulation with brick cladding, 70 years
- close wall insulation, 50 to 70 years
- below ground floor insulation, 50 years
- double glazing, 80 to 100 years
- installation of gas-fired central heating with combination boilers, 10 years
- whole package, 25 to 40 years.

Estimated payback periods for those measures not included in final specification are:

- additional 50 mm loft insulation, 3 years
- 50 mm cavity fill in addition to wall insulation, 50 to 60 years
- low-e double glazing, 70 to 90 years
- installation of gas-fired central heating with condensing combination boilers, 10 to 15 years.

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	50 mm loft insulation	150 mm mineral wool loft insulation between joists
External walls	103 mm brick – 50 mm cavity – 110 mm dense concrete block	Existing walls clad with either 103 mm brick and 60 mm expanded polystyrene, or rendered 60 mm expanded polystyrene
Close walls	Uninsulated	Composite board comprising 12.5 mm wallboard and 19 mm expanded polystyrene fitted internally
Ground floor insulation	Uninsulated	60 mm expanded polystyrene to 0.5 m depth on inner face of blockwork
Windows	Single glazing	Replacement PVC-U windows with double glazing (22 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Bathroom and kitchen extract fans (linked to light switch)
Heating	Coal and electric fires	Gas fires, gas-fired central heating with combination boiler (fan assisted flue), programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From combination boiler system

Table 1 Energy efficiency measures

Item	Top floor 3-bed flat		Grnd floor 3-bed flat	
	Before	After	Before	After
SAP rating	19	89	30	78
Annual space and water heating costs	£490	£112	£429	£136
CO_2 emissions (tonnes/year)	14.8	3.5	12.2	4.0

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Buildability issues

In all but the top floor flats, where boilers were flued through the roof, flues had to be taken through external walls. As a result, it was not possible to site the boilers in existing cupboards. Instead, boilers had to be wall-mounted in a position that made it difficult for the programmer (which could not be sited separate from the boiler) to be operated, especially by elderly tenants. In some flats the exhaust gases were extracted via piping through a bedroom.

Tenant consultation

Nine months before the work was due to be completed a meeting was held at which the refurbishment measures were discussed with the tenants. The aim of the meeting was to explain what improvements were being put in place and to demonstrate the new heating system and how to use it effectively. It was necessary to hold the meeting at this stage because of the BRE work programme. However, the Association, which encourages active tenant participation, while judging the meeting useful, considered that in future such meetings would be better held nearer the time of tenants moving into properties. The meetings would be more effective and be seen as more relevant.

7

NIDDRIE HOUSE, EDINBURGH
HUNTERS HALL HOUSING CO-OPERATIVE

Hunters Hall Housing Co-operative owns 201 properties in the Niddrie area on the southern edge of Edinburgh. The housing described here comprises two 5-storey blocks built in the 1970s and acquired from Edinburgh District Council in 1987 and 1988. Comprehensive alterations and partial demolitions, including reduction of the block heights by one storey, were undertaken to create 44 flats and an office for the Co-operative from the original 52 flats. The tender cost of the work was £1 760 161, equivalent to £39 100 per unit.

The construction is external brick-filled cavity-block walls, concrete floors and mono-pitched roof. Heating was by a warm air system.

Energy efficiency specification

This project, which was undertaken in 1989, was the first building work carried out by the Co-operative. The design was by Johnson-Marshall & Partners and achieved an excellent level of energy efficiency. Households were given the choice of replacement heating system and 75% chose gas-fired combination boilers, rather than the alternative of off-peak electric central heating.

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NIDDRIE HOUSE, EDINBURGH HUNTERS HALL HOUSING CO-OPERATIVE

7

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- loft space insulation, 2 years
- insulation to external walls, 60 to 65 years
- double glazing, 110 to 160 years
- installation of gas-fired central heating, 10 to 20 years
- installation of electric central heating, 25 years
- whole package (with gas heating), 30 to 35 years
- whole package (with electric heating), 45 to 55 years.

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	Mono-pitched uninsulated timber roof	New pitched roofs with 115 mm mineral fibre loft insulation
External walls	103 mm brick – 75 mm cavity with blown fibre insulation – 100 mm block	20 mm external render applied; 80 mm mineral fibre insulation and 13 mm wallboard fitted internally
Stairwells	Open to the outside and including communal drying areas	Stairs enclosures built, drying areas moved to outside
Windows	Timber framed single glazing	Replacement timber frame windows with double glazing (6 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Bathroom and kitchen extract fans (with time delay switch)
Heating	Warm air system	Gas-fired central heating with combination boiler (balanced flue), hall thermostat and programmer. Electric radiant fire **OR** electric off-peak central heating. Bathroom radiant heater. Electric radiant fire
Hot water	Electric immersion heaters	From combination boiler system **OR** electric off-peak immersion heaters (144 litre hot water insulated cylinder)

Table 1 Energy efficiency measures

Item		Top floor 3-bed maisonette		Mid floor 1-bed flat	
		Before	After	Before	After
SAP rating	Gas heating	47	92	54	92
	Electric heating	47	82	54	87
Annual space and water heating costs					
	Gas heating	£425	£152	£266	£99
	Electric heating	£425	£251	£266	£164
CO_2 emissions (tonnes/year)					
	Gas heating	7.1	3.5	3.5	2.3
	Electric heating	7.1	4.4	3.5	2.7

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Energy efficiency measures

The measures included in the final specification were:

- loft insulation within replacement roofs
- internal insulation and plasterboard to external walls
- enclosure of common stairs
- kitchen and bathroom extract fans
- replacement timber framed double glazing
- full gas-fired central heating with combination boiler or electric central heating.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the two flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis showed that excellent SAP ratings were achieved with both gas and electric heating. Space and water heating costs are estimated to have reduced by 64% for flats with gas heating and 40% for those with electric heating. The reductions in CO_2 emissions are estimated at 51% and 34% for the two flat types with gas heating, and 38% and 23% for those with electric heating.

8

JAMES NISBET STREET, GLASGOW
JAMES NISBET HOUSING CO-OPERATIVE

The James Nisbet Housing Co-operative has about 260 properties in the Royston neighbourhood, close to Glasgow city centre. The three blocks of 4-storey housing described in this study were built in the 1960s to standard council designs and contain 56 flats entered by seven closes (common stairways).

The construction has external brick-cavity-brick walls, concrete 'beam and block' floors and pitched roofs. Under-floor electric heating was in use.

Energy efficiency specification

The refurbishment was the second undertaken by the Co-operative and took place in 1991 with a tender cost of £1 818 000, equivalent to £32 400 per unit. The design was carried out by ASSIST Architects who, helped by feedback from the Co-operative, built on the experience of the first phase refurbishment with the introduction of condensing combination boilers and glazed-in south-facing balconies.

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JAMES NISBET STREET, GLASGOW
JAMES NISBET HOUSING CO-OPERATIVE

8

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- loft space insulation, 0.5 years
- installation of overcladding, 30 years
- double glazing, 35 to 40 years
- installation of gas-fired central heating with condensing combination boiler, 3 to 5 years
- whole package, 10 to 15 years.

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated	150 mm glass fibre loft insulation between joists
External walls	Render – 103 mm brick – 50 mm cavity (unfilled) – 103 mm brick	External glass fibre/acrylic overcladding system incorporating 60 mm mineral wool insulation. Overcladding taken to ground level
Windows	Single glazing	Timber framed double glazing (12 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Mechanical extract fans (with humidistat controls) to bathroom and kitchen
Heating	Under-floor electric heating	Electric fires, gas-fired condensing combination boiler (fan assisted flue) with programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From condensing combination boiler system

Table 1 Energy efficiency measures

Item	Top floor 2-bed mid-flat		First floor 1-bed gable flat	
	Before	After	Before	After
SAP rating	9	88	17	85
Annual space and water heating costs	£927	£137	£549	£104
CO_2 emissions (tonnes/year)	9.3	3.3	5.0	2.6

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Energy efficiency measures

The measures included in the final specification were:

- glass fibre loft insulation
- external overcladding system which included 60 mm insulation
- replacement timber frame double glazing
- extract fans in kitchens and bathrooms
- full gas-fired central heating with condensing combination boiler.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the two flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis showed that the low SAP ratings before refurbishment were hugely improved to excellent figures of 85 and above. The annual space and water heating costs were estimated to have reduced by 87% for the top floor flat and 84% for the first floor flat, with reductions in CO_2 emissions estimated at 66% and 52% respectively.

9

ABERDALGIE ROAD, GLASGOW
BLAIRTUMMOCK HOUSING ASSOCIATION

Blairtummock is a community-based housing association with about 350 properties in the large Easterhouse estate on the east side of Glasgow. The nine blocks of 3-storey housing described in this study originally contained 54 flats, the housing being built to standard council designs in the 1950s. The refurbishment work included height reductions and remodelling which reduced the number of units to 40.

The construction comprises external walls of brick-cavity-brick construction with timber floors and pitched roofs. Heating was by gas and electric fires.

Energy efficiency specification

The refurbishment was the first development carried out by the Association and took place in 1991 with a tender cost of £1 230 000; equivalent to £30 750 per unit. The design was by John Le Harivel Architects and, helped by an analysis undertaken by the Energy Design Advisory Scheme, was to a high standard of energy efficiency.

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ABERDALGIE ROAD, GLASGOW
BLAIRTUMMOCK HOUSING ASSOCIATION

9

The range of estimated payback periods*, taking into account the different flat types present, for the main energy efficiency measures are:

- insulation of loft spaces, 2 years
- installation of overcladding, 55 to 80 years
- close wall insulation, 20 to 30 years
- double glazing, 45 to 60 years
- installation of gas-fired central heating with condensing combination boilers, 5 to 10 years
- whole package, 15 to 20 years

*The payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated	150 mm glass fibre loft insulation between joists
External walls	Render – 103 mm brick – 75 mm cavity (unfilled) – 103 mm brick – 16 mm plasterboard	External glass fibre overcladding system incorporating 60 mm expanded polystyrene insulation. Overcladding taken to ground level
Close walls	Uninsulated	12.7 mm wallboard and 50 mm mineral fibre insulation to existing wall
Windows	Single glazing	Timber framed double glazing (12 mm air gap) and draughtstripping
Ventilation	Uncontrolled	Bathroom and kitchen extract fans (with humidistat controls)
Heating	Gas and electric fires	Gas-fired central heating with condensing combination boiler (balanced flue), programmer, room thermostat and TRVs
Hot water	Electric immersion heaters	From condensing combination boiler system

Table 1 Energy efficiency specification

Item	Top floor 2-bed flat		First floor 2-bed flat	
	Before	After	Before	After
SAP rating	12	85	28	91
Annual space and water heating costs	£611	£105	£457	£93
CO_2 emissions (tonnes/year)	6.6	2.7	4.4	2.4

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Energy efficiency measures

The measures included in the final specification were:

- glass fibre loft insulation
- external overcladding system which included 60 mm insulation
- insulation to close walls
- timber frame double glazing
- extract fans to kitchens and bathrooms
- full gas-fired central heating with condensing combination boilers.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the two flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis showed that excellent SAP ratings were achieved; higher than could be typically expected for a refurbished property. The annual space and water heating costs were estimated to have been reduced by 83% for the top floor flats and 80% for the first floor flats, with corresponding reductions in CO_2 emissions estimated at 59% and 45% respectively.

10

CALEDONIA ROAD, HUTCHESONTOWN, GLASGOW
SCOTTISH HOMES

The 24-storey block described in this case study is one of four similar blocks owned by Scottish Homes in the Hutchesontown area on the south side of Glasgow city centre. Each block contains 138 flats built in the mid-1960s to a standard Scottish Special Housing Association design. A large-scale five-phase programme of improvements was initiated by Scottish Homes in 1992, because the area had deteriorated. The first phase was concerned with environmental and security improvements, with the refurbishment of the housing described in this case study being the second phase. This work began in 1994 and included the construction of a purpose-built plant room to house the district heating system boilers. Tender costs for the work were £4 644 590, equivalent to £33 600 per flat.

The block has an *in situ* concrete frame with the external walls being constructed of precast concrete cladding panels and an inner blockwork leaf. Infill areas are blockwork cavity walling, rendered externally. The flat asphalt roof was constructed on an *in situ* concrete deck and was internally insulated during earlier refurbishment work.

This project is the subject of a long-term, in-depth study, being carried out by BCG Associates on behalf of Scottish Homes. Ten dwellings have been monitored for two heating seasons before refurbishment and will be compared with the results for ten similar dwellings for a similar period after refurbishment. The study will take into consideration the effects of temperature and relative humidity as well as energy consumption. In addition, the lifestyles of two sets of tenants are being studied with their cooperation. The study will be in progress until June 1998. This should be borne in mind when considering the current case study, which is based on estimated figures only and an assumed standard lifestyle.

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CALEDONIA ROAD, HUTCHESONTOWN, GLASGOW
SCOTTISH HOMES

10

The range of simple payback periods* for the main energy efficiency measures, taking into account the different flat types present, have been estimated as:

- roof insulation, 20 years
- district heating system, 20 to 25 years
- low-e double glazing, 40 to 100 years
- whole package, 40 to 75 years.

*Simple payback periods were estimated using the cost of both the measure and the associated work necessary to incorporate the measure in the project. The associated work varied from project to project. Therefore payback periods can only be taken as specific to each project and can be indicative only.

Item	Before refurbishment	After refurbishment
Flat roof	25 mm internal insulation	50 mm glass fibre insulation laid externally, oversheeted with aluminium
External	*In situ* concrete frame. External walling of 75 mm precast concrete panels – cavity (50 to 250 mm) – 100 mm blockwork inner leaf	External overcladding fitted, including 150 mm mineral wool insulation
Floor insulation	25 mm insulation below floors	Unchanged
Windows	Timber framed single glazing	Replacement timber frame windows with double glazing (12 mm air gap). Buffer zone conservatories to living room with double glazed windows and triple glazed fixed light panels. All with low-e glass.
Ventilation	Mechanical extract to bathroom, kitchen and linen cupboards	Trickle vents installed to window heads. Windows and doors draughtstripped
Heating	On-peak electric fires, off-peak storage heaters	Gas-fired central heating with one room thermostat per flat. On-peak electric fires in some flats
Hot water	110 litre hot water cylinder with 25 mm thick insulation jacket. On-peak electric immersion heater	125 litre hot water cylinder (pre-insulated with 25 mm rigid foam lagging) fed from district heating system

Table 1 Energy efficiency improvements

Item	Top floor mid-block 1-bed flat		Mid-floor gable 2-bed flat	
	Before	After	Before	After
SAP rating	12	50	45	74
Annual space and water heating costs	£463	£177	£374	£165
CO_2 emissions (tonnes/year)	6.9	3.5	4.6	3.1

The figures after refurbishment have been calculated assuming a conventional gas-fired boiler in each flat. This is because current evaluation methods do not recognise district heating systems.

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions before and after refurbishment

Energy efficiency specification

The refurbishment design was carried out by ASSIST Architects. The specification was drawn up after consideration of both a feasibility study and an energy analysis carried out by the Energy Design Advisory Scheme. In addition, Powerminster, the designers of the district heating system, contributed further advice. The underground heating distribution network was designed by Sheffield Heat and Power.

Energy efficiency measures

The measures included in the final specifications were:

- glass fibre insulation over existing asphalt flat roof; oversheeted with aluminium
- mineral wool external insulation forming part of a rainscreen overcladding
- replacement timber frame double glazing with double glazed fixed light panels; low-emissivity (low-e) glass
- gas-fired district heating system with modular boilers.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats before and after refurbishment. Table 2 gives the results for the flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis shows that good SAP ratings were achieved. The estimated annual space and water heating costs were shown to reduce by 62% for the top floor 1-bed flat and 56% for the mid-floor 2-bed flat. The corresponding reductions in CO_2 emissions are estimated at 49% and 33% respectively.

The payback period for the insulation element of the rainscreen overcladding is not included above as the results would not provide a fair indication of its cost-effectiveness. In this project, the main reason for the installation of the rainscreen cladding was to overcome problems of external fabric deterioration. The average cost per dwelling of the rainscreen overcladding was £7400.

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WAGGON ROAD/DURIE STREET, LEVEN
KINGDOM HOUSING ASSOCIATION

Kingdom Housing Association has about 1200 properties throughout Fife. The 'improvement for sale' described in this case study is on the site of a former Co-operative store built in 1935. All that remained of the Category B Listed derelict building was the stone façade. This was retained as the front elevation of a 2- and 3-storey development of 24 1-, 2- and 3-bedroom flats. Another adjacent eight flats were entirely new build. The solid stone façade is roughly L-shaped and fronts on to both Waggon Road and Durie Street, close to the centre of Leven. Kingdom HA acquired the building from the Co-operative Wholesale Society in 1995.

Tender costs for the 32-flat development were £1 472 200, equivalent to £46 000 per flat.

Energy efficiency specification

The specification for the flats was by Davidson Design and met the Building Standards (Scotland) Regulations (1990). The standard of energy efficiency was, therefore, already high. However, after consultation with the Building Research Establishment (BRE) the specification was modified to include additional loft insulation, improved wall insulation and condensing combination boilers in place of the originally specified standard combination boilers. Another measure was cavity fill, which could not be incorporated by the Association because of NHBC restrictions.

This page forms part of Good Practice General Information Report 46 (GIR 46), 'Energy efficiency in Scottish Housing Association refurbishment projects', produced by BRECSU as part of the Department of the Environment's Energy Efficiency Best Practice programme. For further information on buildings-related topics contact: Enquiries Bureau, BRECSU, BRE, Garston, Watford, WD2 7JR Tel 01923 664258 Fax 01923 664787 E-mail brecsueng@bre.co.uk

WAGGON ROAD/DURIE STREET, LEVEN
KINGDOM HOUSING ASSOCIATION

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For the main energy efficiency measures the approximate range of the costs per flat of both the measure and the associated work necessary to incorporate the measure into the project were:

- insulation of loft space, £130
- internal insulation to existing façade, £560 to £2800
- internal insulation to new build external walls, £400
- internal insulation to new build close walls, £200 to £250
- ground floor insulation, £1200
- double glazing, £1300 to £3100
- extract fans, £350
- installation of gas-fired central heating with condensing combination boiler, £1800
- whole package, £5000 to £9500.

The approximate range of costs for that measure not included in final specification is:

- cavity fill of new build external walls additional to dry lining, £70 to £200.

The flats were newly constructed behind an existing façade so payback period calculations are not applicable.

Item	As built
Roof	New pitched roof with 200 mm mineral wool loft insulation laid between joists, 50 mm across joists
External walls (existing stone façade)	600 mm stone – 25 mm cavity – 12 mm plywood – 100 mm glass wool insulation – composite insulation board (12.5 mm plasterboard and 27.5 mm extruded polystyrene insulation)
External wall (new build)	22 mm render – 100 mm concrete block – 50 mm cavity – 100 mm dense concrete block – 38 mm cavity with 40 mm glass wool insulation – composite insulation board (12.5 mm plasterboard and 27.5 mm extruded polystyrene insulation)
Internal walls (new build)	100 mm concrete block – 50 mm cavity – 100 mm dense concrete block – 38 mm cavity with 40 mm glass wool insulation – 12.5 mm plasterboard
Ground floor insulation	43 mm composite flooring (18 mm chipboard and 25 mm polyurethane insulation) laid on 70 mm battens on concrete
Windows	Timber frame windows with double glazing (16 mm air gap) and draughtstripping
Ventilation	Extract fans to bathroom (linked to light switch) and kitchen
Heating	Gas-fired central heating with condensing combination boiler (fan assisted flue), programmer and TRVs
Hot water	From condensing combination boiler system

Table 1 Energy efficiency measures

Item	1-bed top floor gable flat	3-bed ground floor corner flat
SAP rating	93	83
Annual space and water heating costs	£77	£121
CO_2 emissions (tonnes/year)	2.6	3.9

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions

Energy efficiency measures

The measures included in the final specification were:

- mineral wool loft insulation
- internal insulation to existing façade
- internal insulation to new build external and internal walls
- insulated ground floor
- double glazing
- kitchen and bathroom extract fans
- full gas-fired central heating with condensing combination boilers.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out and table 2 gives the results for the flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis showed that excellent SAP ratings were achieved. The annual space and water heating costs were estimated at £77 for the top floor 1-bed flat and £121 for the ground floor 3-bed flat.

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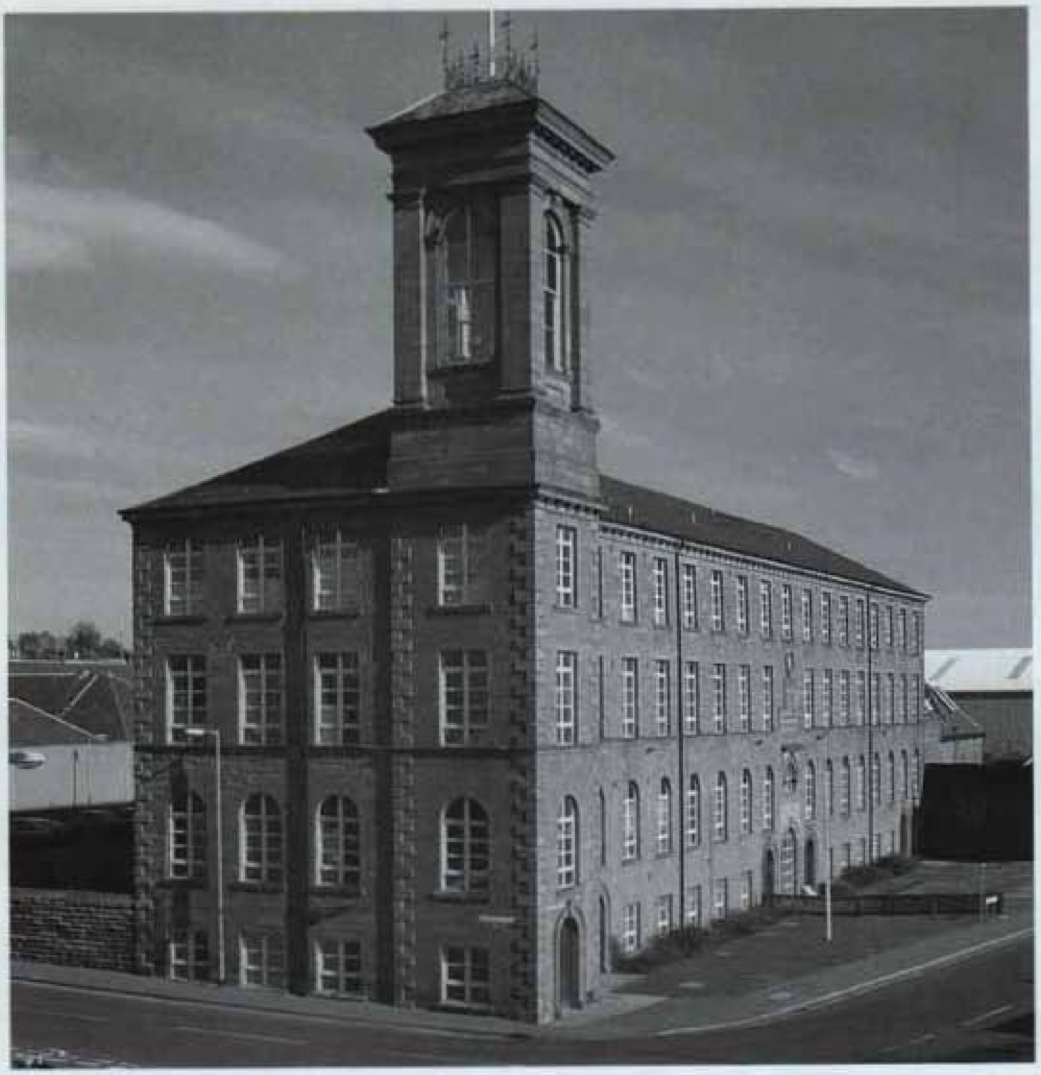
DENBURN WORKS, BRECHIN
HILLCREST HOUSING ASSOCIATION



Hillcrest is a regionally based housing association with 2050 properties in Fife, Dundee and Angus. The housing described in this case study comprises 35 1-bedroom flats constructed within a 4-storey former mill, close to the centre of Brechin. The property, which is Category B Listed, was built in 1867 and was unused when it was acquired by the Association from Angus District Council in 1990. The refurbishment took place in 1992 with tender costs of £1 126 455, equivalent to £32 184 per flat.

The existing construction of solid sandstone external walls and pitched roof was retained. All internal structures were removed. The flats were formed within the remaining structure by the construction of precast concrete floors and blockwork walls. The sandstone façades now form the external walls of the flats.

Energy efficiency specification

The Association has considerable experience of refurbishment projects and their in-house design included several measures contributing to the overall level of energy efficiency achieved.

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DENBURN WORKS, BRECHIN
HILLCREST HOUSING ASSOCIATION

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For the main energy efficiency measures, the approximate range of costs per flat of both the measure and the associated works necessary to incorporate the measure in the project were:

- loft space insulation, £90
- insulation to external walls, £285 to £410
- close wall insulation, £345 to £370
- double glazing, £1880 to £2740
- extract fans, £500
- installation of electric heating, £780
- suspended insulated ceilings, £680 to £800
- whole package, £4000 to £5100.

The flats were newly constructed within a former mill which had not been used as dwellings prior to the refurbishment works so payback periods are not applicable.

Item	Before refurbishment	After refurbishment
Roof	Uninsulated pitched roof	100 mm mineral fibre insulation. Ventilation to loft space
External walls	600 mm thick sandstone	Lined with 80 mm mineral wool insulation behind 13 mm plasterboard
New build blockwork (flat walls and stairwell walls)	–	200 mm dense concrete blockwork. Lined with 80 mm mineral wool insulation behind 13 mm plasterboard
Room heights	Ground floor – 3.0 m First floor – 4.2 m Second floor – 3.8 m Third floor – 3.2 m	Ground floor – 2.3 m First floor – 2.8 m Second floor – 2.5 m Third floor – 2.5 m Room heights reduced using mineral board suspended ceilings with 100 mm mineral fibre insulation
Windows	Timber framed single glazing	Replacement timber frame windows with double glazing (20 mm air gap) and draughtstripping. Replacement windows and single pane safety glass fill the existing openings
Ventilation	–	Bathroom and kitchen extract fans linked to light switch
Heating	–	Electric storage and panel radiators with individual controls
Hot water	–	Electric immersion heaters

Table 1 Energy efficiency improvements

Item	1-bed mid-floor mid-block flat	1-bed top floor gable flat
SAP rating	54	47
Annual space and water heating costs	£205	£243
CO_2 emissions (tonnes/year)	2.5	3.3

Table 2 Estimated SAP ratings, energy costs and CO_2 emissions

Energy efficiency measures

The measure included in the final specification were:

- mineral fibre loft insulation
- blockwork inner leaf and existing stone walls lined with mineral fibre insulation behind plasterboard
- reduction in ceiling heights
- insulation of suspended ceilings
- replacement timber framed double glazing
- extract fans to kitchen and bathroom
- electric central heating.

Standard Assessment Procedure (SAP) ratings and cost-effectiveness

A SAP analysis was carried out for the flats and table 2 gives the results for the flat types estimated to have the highest and lowest SAP ratings after refurbishment. The analysis showed that reasonable SAP ratings were achieved. The annual space and water heating costs were estimated at £205 for the mid-floor flat and £243 for the top floor flat.

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Enquiries Bureau

BRECSU

BRE
Garston, Watford, WD2 7JR
Tel 01923 664258
Fax 01923 664787
E-mail brecsuenq@bre.co.uk

Industrial projects contact:
Energy Efficiency Enquiries Bureau

ETSU

Harwell, Oxfordshire
OX11 0RA
Tel 01235 436747
Fax 01235 433066
E-mail etsuenq@aeat.co.uk

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